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INFLUENZA

An Epidemiologic Study

BY

WARREN T. VAUGHAN, M.D.

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PREFACE.

Following every widespread epidemic or pandemic of influenza, the contemporary literature becomes virtually flooded with reports of scientific studies on the etiology and the epidemiology of the disease. By the time that recrudescences have ceased, interest has usually lagged and eventually research in this subject has practically ceased, only to be revived with the development of the next extensive epidemic.

To one who has had occasion to review the extensive literature of the last pandemic, it becomes apparent that many of the recent writers are uninformed, or at best only partially informed, regarding the rather extensive information accumulated during the 1889 epidemic. The longer one studies the observations made in 1889–93 the more firmly convinced one becomes that the recent pandemic was identical with the former in practically all of its manifestations.

It is desirable that, following each epidemic prevalence some individual or individuals review the literature of the preceding epidemics, acquaint himself with what has been written regarding influenza in the intervening time up to the epidemic prevalence and correlate the work done in these two periods with the various reports regarding the latest epidemic.

The following pages constitute an attempt to correlate the epidemiologic observations of the epidemic thirty years ago with those of the 1918–20 epidemic, and with the observations made during the intervening years.

The house census in the City of Boston and the preparation of this monograph were made possible by the financial assistance of the Metropolitan Life Insurance Company. This organization has devoted a considerable sum of money to the study of influenza in its various phases.

The author is indebted to his chief, Dr. Milton J. Rosenau, for helpful advice and criticism and for the inspiration to carry on this investigation. Dr. W. H. Frost has made many valuable suggestions. Appreciation is also due Mr. Edwin M. Knights, who is responsible for all of the charts, and to Mrs. V. K. Davis, who aided in the tabulation of results of the Boston investigation.

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The house-to-house census was carried out with the co-operation and assistance of the Federated Jewish Charities in Boston and individual members of the social service departments of the Massachusetts General Hospital and the Peter Bent Brigham Hospital.

THE AUTHOR.

Department of Preventive Medicine and Hygiene,
Harvard Medical School, Boston,
September 17, 1920.

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AN EPIDEMIOLOGIC STUDY.*

By WARREN T. VAUGHAN, M.D.

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* From the Department of Preventive Medicine and Hygiene, Harvard Medical School, Boston, Mass.

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INFLUENZA.

AN EPIDEMIOLOGIC STUDY.

SECTION I.

General Epidemiologic Considerations.

Those who seek to find in a study of the epidemiology of epidemic influenza the secret of the causation of the disease, and its ultimate eradication, are probably predestined to at least partial failure. We must call upon the bacteriologist for information as to the causative organism, and in time he may be able to furnish us with satisfactory prophylactic measures, particularly with a successful vaccine.

But while pure epidemiologic studies will not demonstrate the ultimate factor in the etiology, nevertheless these studies do subserve several most important functions. The bacteriologist, the immunologist, the serologist have accumulated a wealth of information since the 1918 pandemic, but as far as definite conclusions concerning the causative agent of the disease are concerned we are no nearer to the truth than we were at the time when Pfeiffer made his original observations. There is no incontrovertible evidence by which one may say that the influenza bacillus is or is not the cause of the disease. We must therefore await further studies and future discoveries. But we cannot await idly in the knowledge that new epidemics of the dread disease will surely come, probably mild ones in the next few years, and certainly severe ones again within a few decades. We must amass all of the available information concerning the mode of action of the disease, its maner of spread, its degree of infectivity, its distribution and the mode of its recurrences, and try to formulate from a study of the available facts some means of protecting ourselves against the epidemic, if not of preventing it entirely.

In short, in the present state of the bacteriologic knowledge of the disease, we may say that the epidemiologic features are the only facts upon which we have to build in planning our defense. Today, the practical work in the eradication of influenza must depend chiefly, if not solely, on the general methods of preventive medicine.

Many valuable monographs have been written on the subject, particularly following the pandemic of 1889–1893, but these have all emphasized features and phases of the disease which seemed at that time to be particularly important. Facts which seemed of extreme importance to the earlier writers are today in some instances considered relatively unimportant, while other phenomena which were but touched upon by the former investigators today have assumed deep significance. For this reason it is worth while to reproduce here the observations made in previous epidemics, and to correlate them with the facts developed in the abundant literature of the last few years, and to draw therefrom inferences as to the life and habits of the influenza virus, and conclusions as to the means of interrupting its progress.

Historical.

The history of influenza can justly be divided into two phases, the first ancient, and the second modern. The latter period begins with the 1889 pandemic. By that time the science of bacteriology had altered our concepts of the etiology of disease and epidemiologists had begun to avail themselves of statistical methods of analysis. For the purposes of this paper, therefore, consideration will be given chiefly to the epidemic of 1889, and a summary of earlier epidemics will be made merely to refresh our minds concerning the antiquity of the disease and the periods of its occurrence. References to the earlier epidemics will be made more particularly in the special discussions later, where points of similarity or difference will be brought out. Further than that it is unnecessary to go in the history of the disease, for the several excellent monographs of 1890 to 1900 tell the historical story in a manner that could scarcely be improved upon.

The great antiquity of epidemic influenza is a fact which I think may be admitted in spite of some who hesitate to accept it because of lack of convincing descriptive evidence. Some believe that the epidemic of the year 412 B.C., described by Hippocrates and by Livy, was an epidemic of influenza. Some have suggested that the epidemic described by Thucydides was the same disease. Parkes remarks that the epidemic pervading the Athenian Army in Sicily in 415 B.C., recorded by Diodorus Siculus, has been supposed to have been influenza. Finkler, in referring to a report by Diodorus of a pestilence occurring in 395 B.C., which broke out in the Greek Army at the siege of Syracuse, and which killed off the soldiers murderously, says that this could not have been influenza. He regards as sufficient argument the fact that the mortality was high. After the epidemic of 1918, one

is more inclined to believe that the epidemic in Sicily may well have been true influenza. We must remember that previous to the last few pandemics the stories have been fragmentary in character and were told, not by physicians, but chiefly by the historians of the time, men who have desired to impress their readers with some idea of the horrible ravages of the disease, and who have doubtless in some instances transmitted the impression of monstrous mortality rates. The early historians were much given to figures of speech, many of which were very telling in conveying the impression desired. Finally, the writers of the middle ages and of earlier times had little or no statistical material on which to base their conclusions. I have no doubt that a historian who during the 1918 epidemic of influenza might have limited his observations entirely to the disease as it occurred at Camp Sherman, Ohio, and who saw 125 robust soldiers dying each day, would have truly written that the disease killed off the soldiers murderously. A further statistical argument in favor of considering the epidemic among the Greek soldiers as quite possibly influenza is the fact that as shown by present day findings these men were all of the age in which the mortality is highest, and were living under sanitary conditions which predispose to high incidence and high mortality.

According to Parkes, in 827 A.D., an attack of "cough" which spread like the plague was recorded. In 876, Italy and later the whole of Europe was attacked, and the army of Charlemagne, returning from Italy, suffered greatly. "Dogs and birds were attacked at this time." In 976 the whole of France and Germany was attacked by a fever whose principal symptom was cough. There is also record of diseases which may have been influenza which were seen in Germany and France in 927 and in England in 996 and 997. All of these records are indefinite and from their nature unconvincing to a critical student. Several investigators have gone over these past records up to 1889 with the idea of determining definitely what plagues were, and which were not, true influenza. The criteria used by the various investigators have differed slightly in some instances. For instance, one chooses to use the record of low mortality in widespread epidemics as the chief characteristic of pandemic influenza, while another emphasizes principally the complications.

The experience of recent years has amply demonstrated that influenza may be characterized by a high mortality or a low mortality; that pneumonia may be prevalent or relatively rare during an epidemic. These features are not truly characteristic of influenza itself. They are phenomena which depend chiefly for their existence on secondary invasion with organisms other than the causative agent of

influenza. It may be that the influenza virus itself is capable of producing pneumonia, but it is generally accepted that an overwhelming majority of the complicating pneumonias are due to secondary infections. One perusing the former literature today would hesitate to state that an ancient epidemic was not influenza merely because it was accompanied by high mortality, nor would he wish to say that it was not this disease because there was no mention of a high incidence of pneumonia. We have had both types within the last few years, as in March and April, 1918, when the disease appears to have been accompanied by a very low mortality and a low incidence of pneumonia, and in October of the same year when the pneumonia incidence and the death rate were both relatively much higher.

Attention should be called to a certain inaccuracy which has appeared in the literature and which has resulted in some instances in a misunderstanding of the entire history of influenza. Finkler says: "According to August Hirsch the first influenza epidemic occurred in 1173 and he places it in his work as the first out of eighty." This has given the impression to some that influenza was unknown previous to that date. Leichtenstern has quoted Hirsch more accurately and thereby given an entirely different meaning to the statement. "August Hirsch says that the first epidemic that can be definitely said to be influenza occurred in 1173." Jordan also conveys the latter impression. He remarks that the first extensive, well described epidemic of influenza occurred in 1510.

Hirsch places the first authoritative influenza epidemic in the year 1173; Zeviani in 1293; Gluge in 1323; Schweich, Biermer and Ripperger in 1387; while Saillant, Thompson, Zuelzer and Leichtenstern accept nothing prior to the first pandemic of 1510 as being unquestionably influenza. It should be remarked here that opinion is not unanimous in every case as to the identity of all epidemics following 1510.

Hirsch concluded that there have been about eighty epidemics since that of 1173. Parkes states that in the fourteenth century there were six epidemics, in the fifteenth seven, in the sixteenth eleven, in the seventeenth sixteen, in the eighteenth eighteen, while in the first half of the nineteenth ten epidemics are on record.

Table I shows in brief review the occurrence of the more important epidemics since the year 1173. Like all similar summaries given in tabular form it possesses the disadvantage of telling only parts of the entire story, and those in only a very general way, but it will suffice as a resumé and for the emphasis of certain phenomena to which attention will be later directed.

Concerning the epidemic of 1889, it is usually stated that it had its

origin in Bokhara in May of that year. As will be seen from the table influenza was present also in Greenland and the Hudson Bay territory in the spring of 1889. The possibility of simultaneous origin in at least two localities in that year will be discussed later. The epidemic remained in Bokhara until August of the same year, after which time it slowly traveled to Siberia where at Tomsk traces of the disease were observed with certainty in October. At that time it was also observed in the Caucasus and in European Russia. It appeared in Petrograd in October, 1889, and remained epidemic until December of that year. The spread of this epidemic throughout the world is indicated in the following table adopted from Leichtenstern:

Spread of Influenza in 1889–90.

Month.	1889–90.
First (October)	St. Petersburg, Moscow, Courland, Livonia Finland.
Second	Berlin, Paris, Vienna, Sweden, Denmark.
Third	London, Holland, Belgium, Balkan States, North America.
Fourth	Capetown, Egypt, Honolulu, Mexico, Japan, Hong-Kong.
Fifth	San Francisco, Buenos Aires, India, Sierra Leone, Scilly Islands.
Sixth	Chili, Kamerun, Zanzibar, Basutoland, Tasmania.
Seventh	British Bechuanaland, Barbados.
Eighth	Gold Cost, Natal.
Ninth	Trinidad.
Tenth	Iceland, Madagascar, China, Senegal.
Eleventh	Kashmir, Katunga.

Between the years 1889 and 1893 according to Leichtenstern there was no period altogether free from influenza. Here and there individual cases or small epidemics sharply localized were observed. In 1893 another epidemic appeared in many places and became quite widespread. There was not, according to this author, the definite geographic progression that had been observed in 1889. This was but a recrudescence, a lighting up from endemic foci remaining after the first wide spread. In the first half of 1893 there was a light spring epidemic, and in November of the same year a larger epidemic swept over the whole of Europe. The height of the latter was reached chiefly in December.

The influenza incidence subsequent to 1893 will be discussed later.

TABLE I.

Influenza epidemics previous to 1889.

Date.	General features.	Site of origin.	Direction of spread.	Localities affected.	Rapidity of spread.
1173	Rather meagre description.	Unknown.		Described in Italy, Germany, England.	Not known.
1239 1311	Described by Zeviani. Records not definite. Not generally accepted.	Described in France.		Invaded all of France.	
1323	Mentioned by Hirsch, Gluge and Zeviani. Most believes it was a typhoid epidemic.				
1327	Mentioned by Zeviani, Hirsch and Gluge. Rather doubtful.			Described in Italy.	
1358	Described by Zeviani. Not generally accepted.			Savoy, Germany, France, Catalonia.	
1387	(Zeviani, Schweich, Gluge, Hirsch and Ripperger.) Characteristic description.	Italy.		Italy, France, Strasbourg, Southern Germany.	
1403	A very short epidemic. (Gluge, Ripperger, Pasquier.)	France.		Described in France. In 1404 it invaded Flanders and Germany (Hirsch).	
1411	Described only in Paris. Extent unknown.	Described only in Paris.		Described by Pasquier as in Paris.	
1414	Characteristic description.			In Italy and France in February and March. In the Danube district between January and April.	
1427	Very characteristic description.			Described in France.	
1438	Cited only by Zeviani.			Described in Italy.	
1482	Very limited description by Mezeray.				

1510	Widespread over all of Europe.	Malta (?) (Webster and Hancock report that it began in Africa).	Generally, from South to North.	Malta, Sicily, Spain and Portugal, Italy, France, Hungary, Germany, Holland, England, Norway.	
1557	All of Europe.	Conflicting information (Asia?).	General direction from South to North in Europe.	Asia, Constantinople, Sicily, Italy, Spain, Dalmatia, Switzerland, France, Netherlands, England.	4 months from Italy to Netherlands. Sicily in June. Nimes in July. Italy in August. Madrid in August. Dalmatia in September. Netherlands in October.
1562 1563	Uncertain information.		Only small epidemics at most.		
1580	True pandemic covering the Orient, Africa and Europe.	Orient (Hirsch) Africa and Malta (Pechlin).	From Asia to Constantinople and in Europe from South to North.	Orient, North Africa, Constantinople, Malta, Venice, Sicily, Italy, Spain, Hungary and Germany to the Baltic, Bohemia, France, Belgium, England, Denmark, Sweden.	France in May. Germany and Hungary in August. England and Rhine Valley in September. Saxony in October.
1587	Apparently quite localized.			Described in Italy and Germany.	
1591	High mortality. Indefinite information.				
1593	Spread over a wide area in Europe.	Said to have commenced in Belgium, "following a violent earthquake," and gradually extended over all the cities of Europe.	Uncertain.		
1626	Local.			Described in Italy.	
1627	In America.		Spread from North America to West Indies and Chili.		
1647	In America (Webster).				
1658	Local.	England (?).		Described in England and in Treptow near Stettin.	
1675	Over Western Europe.	Germany (?).		Germany, Hungary, England, France.	Germany in September England and France in October and November.

TABLE I (*Continued*)

Influenza epidemics previous to 1889.

Date.	General features.	Site of origin.	Direction of spread.	Localities affected.	Rapidity of spread.
1688	Apparently localized in Great Britain and Ireland.	England(?).		Described only in England and Ireland.	
1693	England and the adjacent continent.	Dublin(?).		Dublin, Oxford, London, Holland, Flanders.	One month from Dublin to London.
1709 1712	A period of extensive endemics.	In 1712, onset in Germany.	1712, spread from Germany to Holland and Italy.	Italy, France, Belgium, Germany, Denmark.	Six months from Germany to Italy.
1729	First epidemic said to have originated in Russia and first described as entering Europe from the North-east rather than the South-east. First spread. Pandemic period.	Usually designated as Russia (Moscow). F. Hoffman claimed to have seen the epidemic in Halle in February, 1729.	Russia through Sweden, Poland, Germany, etc. to Italy and perhaps North America.	Moscow, Sweden, Poland, Silesia, Austria, Hungary, England, Switzerland, France, Italy, Iceland.	Moscow in April, 1729. Sweden in September, England in November. Paris in December. Rome in February, 1730.
1732	Second spread. Pandemic period.		Over Europe and America. According to Pelargus it again followed the route from Russia through the North of Europe and then South.		Germany in November. France in January, 1733. Spain and Italy in February.
1737	Not generally recognized.			England, North America, Barbadoes, France.	
1742 1743	Slow spread from Germany. Recurrences in Germany up until 1745.	Began either on the shores of the Baltic Sea or in single cities in Germany.	Occurred in Germany in Jan. and Feb., 1742, and then disappeared to reappear in Switzerland in the spring.	Germany, Switzerland, Italy, France, Holland, Belgium, England.	Germany in January, 1742. England in April, 1743.
1757 1758 1761 1762 1767	A period of related epidemics with complicated geographic pictures and without clear cut direction of spread.	Began either first in North America and spread thence to Europe or else began spontaneously in both hemispheres.	Finkler states that in 1762 influenza first started in Germany and spread thence in a very irregular way over Western Europe. Gluge and Hirsch state that in 1767 the disease appeared simultaneously in Europe and North America.	France, Scotland, America, Barbadoes, Germany, Austria, Hungary, Denmark, England, Ireland, Alsace.	Villalba states that the epidemic in 1767 had traveled over the whole of Europe in a period of two months.

1775 1776	Slow spread through Western Europe.	First appearances in Autumn of 1775 in village of Clausthal in the Harz mountains.	First spread to Vienna, and after a quiescence broke out in France and England and possibly spread to America and China.	Germany, Italy, Austria, England, Ireland, France.	Invaded Vienna in June. Made appearance in Italy in September. In England and France in October, November and December.
1780 1781	Western Europe and possibly Brazil and China.	January, 1780 in France.	Spread to Alsace, Germany and Italy, and in March reported in Rio de Janiero. Appeared in Sept. 1780 on Southern coast of China.		Three months from France to Brazil.
1781 1782	One of the most widespread pandemics. Abundant literature.	China and perhaps India in Autumn of 1781 (Hirsch). English writers connect onset with occurrence of influenza in the British Army in India, Nov., 1781. Wittwer and others begin its history in Petrograd in January, 1782.	Through Siberia and Russia to Petrograd, Finland, Riga, Germany, etc.	China, India, America, Russia, Riga, Germany, England, Scotland, Netherlands, Ireland, France, Italy, Spain.	Moscow, January, 1782. Riga, February. Germany, March. England, April. Scotland, May. Ireland, France and Italy, June. Spain, August.
1788 1789	Throughout all of Europe. One year later in America.	Russia, in March, 1788. "Apparently independent origin in America in Sept., 1789."	West and South. Spread in America in 1789 throughout United States from New York North and South and finally touching the West Indies, South, America and Nova Scotia. Recurrences in single cities of U. S. in 1790.	Russia, Germany, Hungary, Denmark, England, Scotland, France, Italy, Switzerland.	Seven months required to cover this territory.
1799 1800	Local epidemic confined to Northeastern Europe.	Origin in Russia.	Spread West and South.	Russia, Galicia, Poland, Germany, Denmark.	
1802 1803	Local endemic outbreaks covering considerable territory which follow the last period by a quiescence of five months. There appears to have been an unassociated epidemic early in 1800 in China and one in Brazil.	First reported in France.	No clear cut direction. Recurrences until 1805–08. General dissemination throughout North America in 1807.	France, Germany, Italy, England, Switzerland, Central Europe.	

TABLE I (*Continued*)

Influenza epidemics previous to 1889.

Date.	General features.	Site of origin.	Direction of spread.	Localities affected.	Rapidity of spread.
1811 1815 1816 1824 1826	Several epidemics in North America and to some extent in South America.	1807, onset in Massachusetts in February. 1815, onset in Boston in September. 1824, onset in Boston in October.	Usually from New England West and South.	North and South America.	1815, one month from Boston to New York, and five months to South Carolina and Brazil. 1824, three months from Boston to Georgia.
1827	Widespread epidemics throughout Eastern Russia and Siberia.				
1830 1833	Extensive influenza period made up of two or three pandemic periods.	China in January, 1830.	To Manila in September, 1830. Later to South Sea Islands and India. Appearance in Russia in October, 1830, with subsequent spread West and South and on to North America (Feb., 1832).	Entire earth.	Ten months from China to Russia. Four months from Russia to Germany. Two additional months through France, England, Scotland, Sweden, Belgium, Switzerland. Six months from Germany to Italy.
1833	Second pandemic in above period.	Probably Asia.	After an interval of one year Europe was again visited with an extensive plague which attacked the same countries in about the same order.	Europe. (America appears to have escaped this second epidemic.)	Petrograd in January. Berlin and Constantinople in March. Denmark and Sweden, France and Great Britain in April, Italy in May.
1836 1837	Third spread in above period.	Origin rather obscure, possibly in Russia.	West and South as previously.	Europe, Faroe Islands, Mexico, (?) India, Java.	Almost simultaneous invasion at Petrograd, Sweden, Denmark, Germany and England; Egypt, Syria, France, Ireland, Holland, and Switzerland one month later. Italy, Spain and Portugal yet anothe month later.

1838 1847	Every year in this period with the exception of 1840 showed, according to Hirsch, some local epidemic.			1838, February; Island of Bourbon and Iceland. 1838, November; Australia and New Zealand. 1839, Abyssinia. 1841, Germany, Hungary, Ireland. 1842, Belgium, England, France, Egypt, Chili. 1843, Germany, England, Iceland, France, Siberia, the United States. 1844, Germany, England, Switzerland, Cayenne. 1845, Germany and Switzerland. 1846–1847, France, Russia, Constantinople, Brazil, England, Denmark, Belgium, Switzerland.	
1847 1848	Epidemic period throughout Europe without clear cut direction of spread.	Origin uncertain.	Spread not definite, North America in 1848.	All of the countries of Western Europe, West Indies, New Zealand, Newfoundland, Sandwich Islands, Egypt, Algiers, West Coast of Africa.	
1850 1889	Epidemics covering larger or smaller territory every year, but none to compare in intensity with those of 1831, 1833, 1836 and 1847.		1857, began in August in Panama and spread to West Indies and up and down the Pacific Coast. Prevailed in Europe in December.	1850–51, particulary throughout the whole Western coast of South America with later spread to California and Europe. 1852, Australia, Tasmania, South America. 1853, Faroe Islands. 1854, Bavaria. 1855, Europe, spreading rapidly West and South from Petrograd. Later in same year, Brazil. 1857–58, widespread epidemic in both hemispheres. 1860–70, very irregular appearances in Australia, Tasmania, Philadelphia, the Bermudas, Holland, California, France, Switzerland, Africa, Germany, Belgium, Russia, Denmark, Sweden and Turkey. 1874–75, Extensive spread in America, Germany and France, with recurrence one year later in eleven areas of the United States. 1879, America. 1885–88, Re-appeared each year in Petrograd. 1889, (Spring) Greenland and Hudson Bay territory. (May) Bokhara in Turkestan from where the great pandemic of 1889–90 is usually said to have taken its origin.	1855, only one month between Petrograd and Italy.

Table I shows that prior to 1510 the information was so limited as to be not entirely conclusive. We must rely upon the fragmentary descriptions of writers located usually in or near the intellectual centers who described the disease as they saw it in their city or country. We have no way of ascertaining what other countries were invaded, and we possess no method by which we may enumerate the "silent areas," countries which in the absence of a chronicler have not been able to transmit their story.

There have been fourteen very widespread epidemics since 1510, all of which might appropriately be designated as pandemics. They are those of 1510, 1557, 1580, 1593, 1729, 1732, 1762, 1782, 1788, 1830, 1833, 1836, 1847, 1889 and 1918. Some of these have spread farther than others according to the records, but in nearly all we have reports of influenza being present in practically every country provided with a historian. We may find from the table another group in which there have been more or less extensive epidemics, apparently related, but without any general direction of spread. Such are the epidemics of 1709–12, 1757–67, 1802–03, 1838–47 and the period 1850–59. Finally, there are at least ten periods during which relatively small areas have been affected with epidemic influenza. Such for instance is the year 1688 when the disease was apparently localized in Great Britain and Ireland; in the year 1693 when England and the adjacent continent were involved, with little spread elsewhere; and again in 1742, when there was a slow spread through Germany into adjacent countries with recurrences in the former up until 1745.

In England the following epidemics have been recorded, some of them in great detail: 1510 and 1557, described by Thomas Short; 1658 by Willis; 1675, by Sydenham; 1729–1743 by Huxham; 1732–33 by Arbuthnot; 1758 by Whytt; 1762 by Baker and Rutty; 1767 by Heberden; 1775 by Fothergill, who collected observations from many physicians; in 1782 by Gray, Haygath and Carmichael Smith; 1803 by Pearson and Falconer, and a great number of others; 1833 by Hingeston and others; 1837 by Streeten, Graves, and Bryson, etc.; 1847 by Peacock, Laycock and many others; also those of 1855 and 1889–93.

According to Stallybrass, epidemic crests have been reached in England in 1789–90, 1802–03, 1830–32, 1840–41, 1848–51, 1854, 1869–70, 1879, 1890–91, 1898 and 1918 to 1920. The periodicity in multiples of ten years in this latter group is remarkable.

The disease appears to have visited North America in the years 1627, 1647, 1729, 1732, 1737, 1762, 1782, 1789, 1811, 1832, 1850, 1857, 1860, 1874, 1879, 1889, 1900, 1915–1916 and 1918–20. Abbott

speaks particularly of the years 1647, 1655 and 1697–98, 1732, 1762 and 1782 and 1889 as being years of especial epidemic prevalence in this country.

Clinical and Epidemiologic Identification.

Up to the present time we have discovered no one characteristic by which we may say that a case or an epidemic is positively influenza. We have had to rely on the general symptomatology, which indeed is sufficiently characteristic, although so nearly like the symptoms of certain other diseases as to make us hesitate to make an absolute diagnosis, and on the epidemic characteristics. The necessity of an absolute criterion in the clinical diagnosis is particularly felt in the presence of an isolated interepidemic case, or a small endemic outbreak. It is at this point that the opinions of epidemiologists diverge, a divergence which results in two schools of thought in the explanation of the endemic source of epidemic influenza. Are the interepidemic cases and the small localized epidemics due to the virus which causes the great pandemics; are they *influenza vera*, or are they entirely different diseases with similar symptomatology, caused by some other microorganism and should they be designated by some other name? Thus Leichtenstern remarks: "When we go over the records of the years 1173 to 1875, and particularly those of the last century, when the information has been more extensive and more accurate, we find that scarcely a year has passed without news of the epidemic occurrence of influenza at some point or other of the earth. Some of these local and territorial epidemics are merely endemic recurrences of the great pandemics which have left the germ deposited in the various localities. Others of these small epidemics probably have nothing to do with *influenza vera*, but are local outbreaks of *catarrhal fever*."

Contrary to the usual belief, influenza is a disease of quite definite and distinct characteristics, both clinical and epidemiological. The symptoms are clear cut, with sudden onset, severe prostration out of all proportion to the clinical symptoms and to the fever, headache and pain in the back, general body pains, and fever of greater or less degree. There is usually a lack of leucocytosis or a true leucopenia. In uncomplicated influenza there are as a rule no localizing symptoms. There may be a slight soreness of the throat, or a slight cough, but these are at best mild. The fever lasts from three to five days and disappears, while at the same time all of the symptoms clear up with the exception of the profound prostration, which as a rule continues for some time, rendering convalescence surprisingly slow. The pain

in the back may remain for a week or so. This is the description of uncomplicated influenza.

The manner of spread of epidemic influenza is constant in a primary epidemic and the epidemic as a whole has certain features which render it characteristic. The sporadic case has as a rule the same quite clear cut clinical symptomatology, but it fails to manifest the one feature most characteristic of epidemic influenza—a high degree of contagiousness. Further, although the symptoms in themselves are characteristic, there is no one pathognomonic sign by which one may say, "this is a case of influenza," and, finally other disease conditions such as tonsillitis, frequently resemble it so much as to cause error in diagnosis.

This becomes, then, one of the problems in the study of influenza epidemiology. It is a matter of first importance to determine once and for all whether true influenza is with us always, or whether it appears only at the time of the great pandemics. Upon the answer to this question more than upon any other one thing rests our choice of methods of eradication. Any procedures of preventive medicine that may be undertaken on the assumption that the source of pandemic influenza is to be found in one or a few endemic foci, such as the one supposed to exist in Turkestan, would fail utterly should the true condition be that of a universal distribution of a relatively avirulent virus which from time to time from some unknown cause assumes a highly increased virulence.

Before becoming involved in this very complicated question, let us familiarize ourselves completely with the characteristics of the pandemic and epidemic variety of the disease.

General Characteristics of Early Epidemic Outbreaks.

We have described the symptomatology of uncomplicated influenza. It is rare that this clinical picture is seen alone during the height of an epidemic. Complications, chiefly of the respiratory tract, as a rule occur in such a large proportion of individuals that they very nearly dominate the picture. Although caused by various micro-organisms, all of which appear to be secondary factors the results are so characteristic that in the past, descriptions of influenza epidemics have usually been descriptions of the complications of epidemic influenza. Most influenza epidemics are complicated. But we do know from the experience of recent years as well as from history that relatively uncomplicated epidemics of influenza have occurred, and that when

they do so occur a predominant characteristic has been the extreme mildness.

It is a fundamental characteristic of pandemic influenza that early cases in widespread epidemics, as well as in "pre-epidemic increases" are very mild, with a minimum of respiratory complications and with exceedingly low mortality. It is because we are better acquainted with the more severe variety that, when these mild precursors appear we are always in doubt for a time as to their true identity.

In spite of our 20th century erudition, the influenza when it first appeared in mild form in the American Expeditionary Forces in 1918, for a lack of better knowledge as to its cause was called "three-day fever." In Italy in the same year the designation of the disease progressed from pappataci fever through "Spanish grip" and "summer influenza," until finally it was designated influenza, pure and simple. Sampietro in Italy particularly discussed the possibility of the disease being pappataci fever.

Belogu and Saccone, who wrote in May of 1918, decided that the epidemic was not influenza in spite of the manifest clinical similarity, chiefly because of the absence of signs of secondary invasion, such as nervous symptoms, gastro-intestinal symptoms, and pneumonia, and especially because of the rapid recovery after defervescence. They also considered the possibility of pappataci fever and dengue, and ruled out both. They discussed calling the condition "influenza nostras," but reached no definite conclusion. Trench fever was also considered by some. United States Public Health Reports for 1918 record that dengue was reported prevalent at Chefoo, China, during the two weeks ended June 15th, 1918. One week later there was a paragraph stating, "Prevalence of a disease resembling dengue and affecting about fifty per cent. of the population was reported at Shanghai, China, June 15, 1918." It is not impossible that this was influenza.

Zinsser reminds us that Hayfelder, when he saw the influenza as it spread in Petrograd in November of 1889, remarked its close clinical similarity to the description of an epidemic of dengue which had prevailed in Constantinople during the preceding September. Hayfelder, in studying the 1889 epidemic at its onset in Russia and the East, wrote of "Sibirisches Fieber" which was first looked upon as malaria owing to the apparently complete absence of the complicating lesions habitually associated in our minds with influenza.

The same difficulty in early identification was experienced in this country in 1918. At the end of March of that year the author who

was stationed at Camp Sevier, South Carolina, was one of a Board of Officers appointed to investigate a disease which had broken out among troops stationed at that camp. At that time the line troops consisted of three infantry regiments and three machine gun battalions. On the day following a parade in the city of Greenville a considerable number of men in three out of the six organizations suddenly took ill. There were a few isolated cases in other organizations, but in the one infantry regiment and two machine gun battalions the regimental infirmaries were filled, and some cases were sent to the base hospital. Nearly all were very mildly ill and exhibited the symptoms of pure uncomplicated influenza as described above. The onset was sudden, there were the usual pains and aches, the bowels were regular, there was a feeling of discomfort in the pit of the stomach in many instances, and there were no sore throats and very little cough. Recovery was as a rule very rapid, although about a dozen of the entire number developed pneumonia and some of these died. Physical examination of those only mildly ill and who remained in the regimental infirmary showed as a rule nothing, but in some instances scattered fine moist rales near the hilus of the lungs. In some of the organizations the disease was definitely spread down rows of company tents. Careful bacteriologic examination was made at the time and the predominating organisms were found to be a gram-negative coccus resembling micrococcus catarrhalis, and a non-hemolytic streptococcus. This was in uncomplicated cases.

The Board decided that the disease should be called influenza, but our only basis for such decision were the clinical symptoms and the contagious character. At that time none of us dreamed of any possible connection with a severe epidemic to occur later, and laboratory search for influenza bacilli which was carefully made in view of the clinical diagnosis showed none of these organisms to be present.

At about the same time a similar epidemic was being experienced at Fort Oglethorpe, Ga. V. C. Vaughan, in describing this epidemic, remarks: "A disease strongly resembling influenza became prevalent in the Oglethorpe Camp about March 18, 1918. It soon assumed pandemic proportions. Within two weeks every organization in Camp Forrest and the Reserve Officers Training Camp was affected.

"The symptoms were as follows: Headache, pain in the bones and muscles, especially the muscles of the back, marked prostration, fever, sometimes as high as 104 degrees. Sometimes there was conjunctivitis, coryza, a rash and possibly nausea, recovery taking place in a few days.

"In all organizations the epidemic was first located in companies before it became general.

"The incubation period was short, not over one or two days.

"Some organizations suffered more than others for no apparent reason.

"It is probable that the epidemic disease was recently brought to these camps. If it is genuine influenza, and the epidemiological features no less than the leading symptoms seem to point to that disease, there is here offered the most reasonable explanation of the outbreak which is now possible. No other disease spreads so fast or is so prostrating, considering its symptoms."

We will quote at some length from the report of Zinsser of the Chaumont epidemic in France in 1918, because of the excellence of the description, and particularly because Zinsser has followed three successive epidemics with successive increases in the complications and corresponding transformations in the clinical picture. It is worthy of special note that he has remarked that the influenza, as first seen at Chaumont, showed nothing in the symptoms that would suggest a predominant respiratory tract infection.

"It will be useful to discuss briefly the early cases as we saw them during the Chaumont epidemic, not because the observations made there add much that is new from a clinical point of view, but because they will remove any possible ambiguity concerning our conception of influenza in its pure uncomplicated form.

"As far as we can judge the little outbreak at headquarters was typical of the first advent of epidemic influenza in many places. The population of the town, at the time, consisted of a large office personnel attached to the military administration, scattered as to billets and places of work; of military units living in barracks and eating at common messes; and of the townspeople. The epidemic descended upon individual military units with the suddenness of a storm, striking a considerable percentage of the men, perhaps most of the susceptible material, within less than a week, and ending almost as abruptly, with only a few isolated cases trailing behind. Among the more scattered office workers and among the townspeople it was disseminated more gradually and trailed along for a longer period.

"These early cases were clinically so uniform that a diagnosis could be made from the history alone. The onset was almost uniformly abrupt. Typical cases would become ill suddenly during the night or at a given hour in the day. A patient who had been perfectly well on going to bed, would suddenly awake with a severe

headache, chilliness, malaise and fever. Others would arise feeling perfectly well in the morning, and at some time during the day would become aware of headache and pains in the somatic muscles.

"The typical course of these cases may be exemplified by that of J. T. W., a draftsman attached to the 29th Engineers. He was perfectly well until May 20th, working regularly, his bowels and appetite normal, considering himself healthy. On May 21st, at 4:30 A.M. he awoke with a severe headache. He arose, forced himself to eat breakfast and tried to go to work. He began to feel feverish and chilly. At the same time his headache became worse, with pains in the back, and burning in the eye balls. At 2 P.M. he reported sick, and was taken to the hospital with a temperature of 102.8 degrees. At midnight his temperature dropped to 101.6 degrees, and came down to normal by noon of the 22d. As he recovered he developed a slight sore throat, great soreness of the legs and a very slight cough. He recovered completely within a few days.

"These cases with a few exceptions developed no rashes. One or two of them had blotchy red eruptions which we felt incompetent to characterize dermatologically. The leucocyte counts ranged from 5,000 to 9,000. A very few went above this. Sometimes there was a relative increase of lymphocytes, but this was by no means regular. The few spinal fluids that were examined were normal. As to enlargement of the spleen, we can say nothing definitely.

"Soon after this we observed the disease in a Division, the 42d, then holding a part of the line in front of Baccarat. Here it had already developed a somewhat different nature, due, we believe, to the fact that the men of this Division were not, as were those at Chaumont, living in a rest area, but were actively engaged in military operations, working, sleeping, and eating under conditions that involved greater fatigue, less protection against weather, and greater crowding in sleeping quarters. The Baccarat cases were much mroe frequently catarrhal; sore throats, coughs and more serious respiratory complications were more common. However, they were usually coupled unmistakably with an underlying typical influenzal attack, sudden onset, pains and short lived fever. Moreover, there were a great many of the entirely uncomplicated cases interspersed with the others.

"Still later, in September, October and November, respiratory complications were so frequent and severe, came on so early in the disease, and the pneumonia mortality became so high, that the fundamental identity of these later cases with the early three day fever

might easily have been lost sight of by observers who had not followed the gradual transformation.

"In consideration of these facts, it is apparent that etiological or other investigations can throw no light upon the problems of influenza unless they are carried out with clearer understanding of the differentiation between the complications and the basic disease.

"The serious respiratory infections of the bronchi and lungs we can set down with reasonable certainty as complications due, certainly in the overwhelming majority of cases, to secondary bacterial invaders. It is a matter of considerable difficulty, however, to know exactly where the basic disease stops and the complications begin; and whether we must regard the mild sore throat and conjunctival injection which so often accompany the simple cases as a part of this basic clinical picture, or as the simplest variety of complication. This is much more than an academic question, since, as we shall see, the bacteriological analyses of such lesions have played an important role in etiological investigations."

Symptoms in Former Epidemics.

The difficulty in making a decision in the presence of an epidemic is very similar to that of deciding whether the epidemics of former times were in each case influenza. Some few have been recorded in which the description has corresponded fairly well to that of primary uncomplicated influenza. Thus, concerning the epidemic of 1557 in Spain, Thomas Short wrote as follows: "At Mantua Carpentaria, three miles from Madrid, the epidemic began in August . . . There it began with a roughness of the jaws, small cough, then a strong fever with a pain of the head, back, and legs. Some felt as though they were corded over the breast and had a weight at the stomach, all of which continued to the third day at furthest. Then the fever went off, with a sweat or bleeding at the nose. In some few, it turned to a pleurisy or fatal peripneumony."

Most of the descriptions, however, have been of a general character and include descriptions of the complicated periods of the epidemic. One of the more complete of the early descriptions was that by Lobineau in 1414, who wrote: "C'était une espèce de rhume, qui causa un tel enrouement que les chastelets furent obligez d'interrompre leurs séances; on dormoit peu et l'on souffroit de grandes douleurs à la teste, aux reins et par tout le reste du corps; mais le mal ne fut mortel que pour les vieilles gens de toute condition."

With this exception we possess no very good or complete descrip-

tion of influenza prior to the epidemic of 1510. After that time they have as a rule been detailed enough to enable identification. Hirsch bases his conclusions concerning the year 1173 chiefly on the following quotation: "Sub hisdem diebus universus orbus infectus ex aeris nebulosa corruptione, stomacho catarrhum causante generalem tussim, ad singulorum perniciem, ad mortem etiam plurimorum immissam vehementer expavite." Nearly all that we have to go on in this description is the widespread incidence of the disease and the presence of respiratory symptoms, particularly cough. In 1323 the description emphasizes only the high morbidity. Thus, Pietro Buoninsegni writes: "In questo anno e d'Agosto fu un vento pestilenzia le per lo quale amalò di freddo e di febbre per alcuni dì quasi tutte le persone in Firenze e questo madesimo fu quais per tutta Italia." The same author describes the epidemic of 1327, emphasizing again the high morbidity and in addition the low death rate: "In detto anno e mese fu quasi per tutto Italia corruzione di febbre per freddo; ma pochi ne morirono." Again in 1387, he emphasizes the same two features.

Pasquier, in writing of the epidemic of 1403 in France, says: "En Registres de Parlement on trouve que le vingt-sixième jour d'avril 1403 y eut une maladie de teste et de toux, qui courut universellement si grande, que ce jour-là le Greffier ne pût rien enrégistrer et fut-on contraint d'abandonner le plaidoyé." Here the high morbidity and the symptoms, particularly cough and pain, are emphasized. In 1414, Baliolanus describes again the high morbidity and symptoms, particularly cough and hoarseness: "Eoque frigore humanis corporibus concepto . . . tussis maxima atque raucitas orta unde nullus pene ordo, aetas et sexus liber evasit." In 1411, Pasquier writes the following: "En 1411 y eut une autre sorte de maladie dont une infinité de personnes furent touchez, par laquelle l'on perdoit le boire, le manger et le dormir . . . toujours trembloit et avec le estoit si las et rompu que l'on ne l'osoit toucher en quelques parts. Sans qu'aucune personne en mourut."

Subsequent to 1510 descriptions have been as a rule more definite. There are, however, exceptions to this statement and these fall in the epidemics concerning which there is some dispute.

Manner of Spread.

More characteristic and more important from an epidemiologic standpoint than the symptomatology in general, as we have discussed it, is the mode of development of the epidemic as a whole.

Human intercourse.—Before the days of bacteriology the contagiousness of the disease was little discussed. Its infectiveness was in fact not universally established until the epidemic of 1889–1890. One of the first writers who attempted to see in the influenza a contagious disease was Ch. Calenus who wrote in 1579: "Contagiosum dico morbum, quia etsi quidem ab occulta quadam coeli influentia, principaliter eum profisci haud dubium est . . . eo in loco quo jam grassabatur inter homines citius eos invadabat, qui cum affectis frequenter conversabantur, quam eos, qui a consuetudine affectorum studiose abstinebant." This keen observer saw that those who carelessly exposed themselves to close contact with cases of influenza were more likely to develop the disease than those who protected themselves in every way possible. The "contagious" school first developed in England, where Haygarth, Hamilton, Gray, Hull, Duggard, Bardsley, and others, in 1775–1803 described the disease as being not in the air, but in a specific contagion. Others who considered influenza a contagious disease were Simonin, Lombard, Petit de Corbeil (1837), Blanc (1860), and Bertholle (1876).

Watson (1847) quotes Cullen as saying that this species of catarrh proceeds from contagion. He, himself, is not convinced of this fact. He says the visitation is too sudden and too widely spread to be capable of explanation in that way. "There are facts in the history of influenza which furnish a strong presumption that the exciting cause of the disorder is material, not a mere quality of the atmosphere; and that it is at least *portable*. The instances are very numerous, too numerous to be attributed to mere chance, in which the complaint has first broken out in those particular houses of a town at which travelers have recently arrived from infected places. . . . What I wish to point out now is the fact that the influenza pervades large tracts of country in a manner much too sudden and simultaneous to be consistent with the notion that its prevalence depends exclusively upon any contagious properties that it may possess."

Parkes, writing in Reynolds' System of Medicine in 1876, views the subject more as we see it today: "The rapidity of the spread would seem at once to negative any connection between human intercourse and the propagation of the disease; yet there is some affirmative evidence. It does not appear to follow the great lines of commerce; but when it has entered towns and villages in which the investigation can be carried on, it is curious how frequently the first cases have been introduced, and how often the townspeople nearest the invalids have been first affected. In this country especially, Haygarth in 1775 and

1782, and Falconer in 1802, collected so many instances of this that they became convinced that its propagation was due entirely to human intercourse. So also, when it passes through a house, it occasionally attacks one person after another. But if it is introduced in this way it afterwards develops with marvelous rapidity, for we cannot discredit the accounts of many thousands of persons being attacked within a day or two, which is quite different from the comparatively slow spread of the contagious diseases. This *sudden* invasion of a community makes it, to many persons, appear highly improbable that any effluvia passing off from the sick should thus so rapidly contaminate the atmosphere of a whole town.

"Still, we must remember how singularly, of late years, the knowledge of the introduction of cholera by persons coming from infected districts has increased, and how very striking are the instances of this kind already recorded in several works on influenza.

"In some cases, again, isolation or seclusion of a community, as in prisons, has given immunity; or at least that community has not been attacked."

The great rapidity of spread has caused even in 1918 some temporary doubt as to the contagiousness of the disease. Thus, Zinsser wrote:

"The opinion of direct and indirect transmission from man to man is also well supported by a detailed study of the epidemiology of individual outbreaks. In our own experience with epidemics such as those at Chaumont, Baccarat and other places, the suddenness with which the malady attacked large numbers of people at almost one and the same time, caused me at first to be exceedingly skeptical of accepting transmission by contact as the only means of conveyance. We considered food and insect transmission as possibilities, and tried our best to find grounds for involving such agencies. But in every case we were forced to return to the conclusion that direct and indirect contact between men came nearest to doing justice to all observed facts."

There have been many examples reported from personal experience to show that influenza is transmitted from man to man. Two objections, however, have had to be met, before this view was generally accepted. First, it has been claimed by some that the disease spread more rapidly from an assumed focus than individuals could travel, and second, that instances were on record of cases occurring spontaneously in isolated communities. Yet a third argument formerly raised against the contagious character of the disease was the claim that it

broke out in mass attacks, that large numbers became ill on the same day without the occurrence of isolated antecedent cases. The splendid work of epidemiologists following the 1889 epidemic appears to have answered all of these objections. Many, such as Leichtenstern, have gone into great detail on this subject. In fact, at that time this was the question of greatest importance. Today we assume the correctness of the hypothesis, and pass on to consideration of other subjects of more recent development. We will, therefore, review very hurriedly some of the evidence quoted to prove that influenza is transmitted only from man to man and only by human intercourse.

Isolated places.—Has it ever been shown that individuals completely isolated from communication with communities where influenza is present have, during an epidemic, developed the disease? Leichtenstern, after a comprehensive review, concludes as follows: "We have not a single example on record where influenza has attacked individuals in completely isolated localities, as on mountain tops and mountain passes. Study of this has been undertaken in Switzerland by F. Schmid. The same has been true of ships at sea, as has been shown chiefly from the English Marine Reports. There have been reports of influenza occurring in mid-ocean and particularly in the earlier epidemics, but the information has been insufficient."

Parkes at even an earlier period observed: "I cannot but consider that we require better evidence of ships being attacked in mid-ocean. In some of the quoted instances the ships had been at a port either known to be infected or in which influenza was really present, although it had not become epidemic. As we are ignorant of the exact period of incubation some men may have been infected before sailing."

Critical investigation into stories of spontaneous infection in isolated localities such as ships at sea and island lighthouses will quite invariably demonstrate that these popular reports have been distortions of the actual facts. One or two examples will suffice. Abbott records an example: "An impression having gained some credence that influenza had appeared on board the squadron of naval vessels which sailed from Boston in December, 1889, while on their course across the Atlantic and before their arrival in Europe, a letter was addressed by the writer to the Bureau of Medicine and Surgery of the United States Navy for information upon this point, to which a reply was received, as follows:

"The 'Chicago,' 'Boston,' 'Atlanta' and 'Yorktown' left Boston December 7, 1889, for Lisbon, Portugal. The first three arrived at Lisbon on December 21st without having touched at any port *en route.*

The 'Yorktown' arrived at that port December 23d, having stopped about twenty-four hours at Fayal, Azores . . . Influenza first appeared on the 'Chicago' December 23d, on the 'Boston' December 28th, on the 'Atlanta' December 30th and on the 'Yorktown' December 28th.

"Influenza was prevailing in Lisbon at the date of arrival of the squadron."

In March, 1920, the author was notified of a somewhat similar story which he undertook to trace. The results show well the inaccuracy of verbal transmission through several individuals. A letter was first sent to the Quarantine Officer at Portland, Maine: "It has been reported to us that in a lighthouse just outside of Portland, Maine, there has been a rather interesting prank played by influenza. We are told that three men and one woman live in the lighthouse; that during the 1918 influenza epidemic the woman contracted the disease while none of the men became sick, and that in the present epidemic all three of the men became sick with the disease and the woman remained well. It was claimed that they had had no communication with the mainland for some time before the men became ill," etc.

The reply was as follows: "I have inquired of the Light House Inspector's office in Portland and they know of no stations to which the terms of your inquiry would apply.

"At the Boon Island station, there are three keepers with families. At the Half Way Rock station, there are three keepers but no woman. The Inspector does not seem to know of any station where there are three men and one woman."

A second letter, sent to the Inspector of Lighthouses at Portland brought corroborative information:

"The Boon Island Light Station was stricken by this epidemic in the following manner: The keeper, his wife and five children were all stricken, the keeper himself having had the hardest battle, having apparently been subject to same while ashore in Portsmouth, N. H. after provisions, supplies, etc. The 2d assistant's wife and two children were also stricken, but the 2d assistant, himself, and the 1st assistant keeper did not contract the malady in spite of the fact that they were all confined on a small island working together at the station.

"During the year 1920 none of the keepers or their families, consisting of thirteen in number, were affected. The Halfway Rock Light Station where three keepers are employed did not contract this malady either in the years 1918 or 1920.

"For your information I might add that during the inspection trip in the months of January, February and March, 1920, all of the light stations in this district were visited, and it was found that they were all enjoying good health and had not been visited by the epidemic, with the possible exception of three stations which are located either on the mainland or close to where the keeper or his family were able to visit the nearby cities or towns."

Although it has not been shown that completely isolated places have been visited by the disease, there is abundant evidence that such places have remained influenza free as long as the isolation has remained complete. Islands and lighthouses, which have not been in communication with the mainland, individuals living isolated on mountain tops, and ships at sea remained free from influenza even in the presence of a pandemic, as long as they did not come into communication with individuals sick with the disease. The following places remained free from influenza throughout the 1889 epidemic: the Isle of Man, several of the islands of the West Indies, particularly the Bahamas, Granada and St. Lucia, also the British Honduras, British Guiana, and the Seychelle Islands.

Even in 1918, when the paths of commerce reached nearly every portion of the world, we have examples of relative immunity of isolated places. Thus we know that the Esquimaux were attacked late in the course of the pandemic, and we have the statement of Barthélemy who traveled in 1919 to some of the oasis towns of the Sahara Desert, and there discovered that there had not only been no influenza up to that time, but also that they had not even heard of the pandemic.

Another type of isolated place is the closed institution. As early as 1709, Lancisi remarked that the prisons of the Inquisition in Rome remained free from influenza. Twenty-one prisons in Germany in 1889–90 remained entirely free from the disease. This was true of 39 prisons in England, some of which were in cities where the epidemic was most extensive. Linroth, who observed this same phenomenon in Sweden, makes the wise remark that, "the influenza conquers more easily the space of 500 to 1,000 kilometers than it does the small barrier made by a prison wall." A convent in Charlottenburg housing one hundred women remained entirely free during the 1889–90 epidemic.

As a rule institutions of this sort have been unable to maintain a complete quarantine throughout the period of an epidemic, and the relative immunity has been demonstrated more in late invasions, at a time when the restrictions have become somewhat lax. Thus, in 1918, Winslow and Rogers, report that in an orphan asylum in New Haven,

Connecticut, which had completely escaped during the month of October when the epidemic was at its height, one of the Sisters and the priest in charge came down with influenza about December 15th. By the 27th of December 127 cases had occurred in the institution within twenty-four hours, and by January 7th there had been 424 cases, with seven deaths out of a total population of 464. The probable source of the sudden outbreak of December 27th seems to have been the Sister first affected who, when convalescent, resumed her duties in the kitchen, which included the inspection and handling of the milk given out to the children.

Crowd gatherings.—Yet another phenomenon which would lead us to conclude that human intercourse is the most potent factor in the transmission of influenza is the fact that there is frequently a high increase in the influenza rate following crowd gatherings. Parkes observed long ago that persons in overcrowded habitations, particularly in some epidemics, suffered especially, and several instances are on record of a large school or a barracks being first attacked and the disease prevailing there for some days, before it became prevalent in the towns around.

In England, the weekly market played an important role in the spread of the disease in 1889. One frequently saw such reports as that: "The first case of influenza was a man who went to London daily." Or, "All the earliest cases were men going to London daily, while their wives and families were later affected."

In the epidemics at San Quentin Prison, it was noted that apices of incidence usually occurred on Tuesday and Wednesday. During the first epidemic it was these days of the second and third weeks. Stanley sees a direct connection between this fact and the fact that every Sunday morning large groups of the men were crowded together in a comparatively small auditorium where they saw moving pictures. On Sunday, October 20th, they sought to eliminate this source of spread by having a band concert in the open air, but the prisoners crowded around the band and were loud in their cheers, and on the following day there was a large increase in hospital admissions.

On November 24th after the second epidemic had apparently ceased the picture shows were again started after having been closed for over six weeks. The following Tuesday and Wednesday twenty-four well defined new cases were admitted to the hospital. On Thanksgiving Day there was a field meet between the various departments of the prison. About 200 prisoners took active part, while 1,600 prisoners were spectators. The meet was held in the open air,

but the prisoners were closely packed and they cheered and yelled. For the three days following this celebration there were 9, 5 and 8 patients admitted respectively.

In discussing the recrudescence of influenza in Boston in November and December, Woodward remarks as follows:

"Whether or not it may be more than a succession of coincidences it is certainly of interest to note that the November outbreak of influenza showed itself three days after the Peace Day celebration on November 12th, when the streets, eating places and public conveyances were jammed with crowds; that the December epidemic began to manifest itself after the Thanksgiving holiday, with its family re-unions and visiting; and that reported cases mounted rapidly during the period of Christmas shopping, reaching a maximum a week after the holiday." That this may have been a coincidence is indicated by the fact that, according to reports by Pearl and others this was not consistently true in other large cities.

Dr. Meredith Davies records the case of a hostel in Wales accommodating 200 students. Infection was introduced on October 19th on the occasion of a dance attended by some students from an infected institution in the neighborhood. Four cases occurred on the 20th and within the short space of five days seventy-nine students out of the 200 were attacked.

Parsons found numerous similar examples in the epidemic of 1889. In 1918 it was frequently observed that among American Soldiers in France, those troops quartered in barracks suffered a much more rapid spread of the disease than those billetted out among the houses of the towns.

Mass attack.—Another argument formerly raised against the contagious character was the claim that it broke out in mass attack, and large numbers became ill on the same day without the occurrence of isolated antecedent cases. The first cases of such epidemic diseases as the plague and small pox became a matter of record because of the accompanying high mortality, while in influenza, with its relatively low death rate the record usually begins only after a comparatively large mass of individuals have been attacked.

Watson in 1847 observed as follows: "Although the general descent of the malady is, as I have said, very sudden and diffused, scattered cases of it, like the first droppings of a thunder shower, have usually been remembered as having preceded it. The disorder is most violent at the commencement of the visitation; then its severity abates; and the epidemic is mostly over in about six weeks. Yet the

morbific influence would seem to have a longer duration. In a given place nearly all the inhabitants who are susceptible of the distemper suffer it within that period, or become proof against its power. But strangers, who, after that period, arrive from uninfected places have not, apparently, the same immunity."

Parkes in 1876 observed that, "When the disease enters a town it has occasionally attacked numbers of the inhabitants almost simultaneously. But more frequently its course is somewhat slower; it attacks a few families first and then in a few days rapidly spreads; the accounts of thousands of persons being at once attacked at the onset of the disease are chiefly taken from the older records, in which the suddenness of the outbreak is exaggerated. Frequently, perhaps always, in a great city the outbreak is made up by a number of localized attacks, certain streets or districts being more affected than others, or being for a time solely affected, and in this way it successively passes to different parts of the city. It has generally occurred in a great city before appearing in the smaller towns and villages round it and sometimes these towns, though in the neighborhood, have not been invaded for some weeks.

"In some cases and perhaps a large number, it breaks out after persons ill with influenza have arrived from infected places.

"The decline in any great town is less rapid than its rise, and usually occupies from four to six weeks, or sometimes longer."

Detailed studies of the Munich epidemic of 1889 and numerous similar studies of the recent epidemic, which will be referred to later, have shown a period of two or three weeks of steadily increasing numbers of cases before the height of the epidemic was reached.

Droplet infection and spread through inanimate objects.—The actual mode of spread of the virus of influenza from one individual to another is unknown. The more generally accepted explanation is that the infecting agent leaves the body through the respiratory tract, usually in the spray of coughing or talking; contagion is by droplet infection, as is sometimes the case in other respiratory infections. Thorne and others have called attention to the capillary congestion of the conjunctivæ very early in the disease. They suggest that possibly the mucous membrane of the eye is the site of infection.

There has recently been considerable discussion concerning the spread of influenza through inanimate objects.

Leichtenstern reviews the reports of 1889–93 in which influenza was supposed to have been transmitted through wares, merchandise and other inanimate objects. He concluded that the evidence in all

of the cases cited was insufficient for conclusive proof. Such an example was the supposed importation of the disease in goods sent from Russia to the Grands Magazins du Louvre at Paris. In one day 100 people became ill and in a few more 500 were sick with influenza. The explanation was that the germs had been imported in goods sent from Russia to the store. Detailed investigation showed that this could not have been the case because no goods had been received from Russia for a period of three years. Another example is that of one of the two winter caretakers at the St. Gothard Hospice. One of the two men went down into the valley where he purchased supplies. Ten days after his return the man who had remained in the Hospice fell ill with influenza while his comrade remained well. It was stated that influenza was introduced into Basel by goods shipped to that place from the Magazins du Louvre in Paris. The first case occurred in a man who had been working at unpacking these goods.

Lynch and Cumming believe that droplet infection plays but a minor role in the spread of sputum-borne diseases, but that insanitary methods of washing dishes and eating utensils was the chief cause for the high rates of "sputum-borne" infections both in army and civilian life in 1918. They found that among 31,000 troops eating from tableware which was cleaned by kitchen police, the influenza rate was 51 per 1,000, while among 35,000 eating from mess kits which each individual washed himself the rate was 252 per 1,000. "Eighty-four per cent. of the cases occurred among those whose hands were contaminated by washing their own eating utensils."

Among 17,236 employees of hotels, restaurants and department stores, who ate from machine washed dishes, there occurred 349 cases of influenza, while among 4,175 who ate from hand washed dishes there were 429 cases. The rate was but 20 per 1,000 in the former, while in the latter group it reached 103 per 1,000. Here again the chances of infection between the two groups were as one is to five.

These authors have records covering 252,186 individuals in scattered institutions in the United States. Among those eating from machine-washed dishes the rate was 108 per 1,000 while those eating from hand-washed dishes suffered at the rate of 324 per 1,000. The ratio was 1 to 3 between the two groups. Seventy-five per cent. of the cases occurred in that group which ate from dishes not disinfected with boiling water. They do not state the number of individuals in each of the two groups.

Lynch and Cumming claim that in the act of coughing only a few organisms are expelled from the mouth, rarely over 1,500, and con-

clude that transmission by direct contact through the air route but rarely, if ever, takes place. While about 1,500 organisms are expelled onto the floor by an act of coughing, a sterile glove wiped across the lips may pick up nearly 2,000,000 organisms. Such organisms may be readily transferred to inanimate objects which are handled by many people.

Hemolytic streptococci and pneumococci may be isolated with great regularity from the hands of carriers or patients, from table ware, inanimate objects touched by these patients, and from floor dust. Diphtheria and tubercle bacilli have been isolated from the hands and eating utensils of patients. The average count of a large number of restaurant dishwater specimens was 4,000,000 bacteria per c.c. The temperature of this water averaged 43° C. and the dishes were practically never scalded. The water was often so highly polluted, "that the dishes are more highly contaminated after they are washed than before washing begins. The spoon or fork is often freer from organisms just after being used by the restaurant patron than when taken from the restaurant's polluted dish water."

Major John S. Billings, epidemiologist at Camp Custer, reported that one of the larger organizations did not properly observe the regulation requiring that all mess kits and table equipment be properly sterilized. The disease appeared early and spread unusually rapidly in this particular organization.

In summarizing the subject of transmission through utensils, we may say that the evidence is suggestive but inconclusive. It is possible, even probable, that this is one mode of transmission. That it is the most important has not been proved. Lynch and Cumming do not take into consideration that the regiments with more sanitary methods of cleansing the dishes are apt to be those regiments with more sanitary habits throughout their daily routine. Those restaurants using mechanical dish washers are usually the cleaner restaurants.

Pontano in Italy is quoted by the Office International d'Hygiène Publique as having observed in his epidemiological study that there was a constant connection between the living conditions and the severity of the complications. Notable differences were observed in neighboring houses according to the hygienic conditions of the various households.

Healthy carriers and convalescents.—Leichtenstern, who apparently accepted the Pfeiffer bacillus as the cause of influenza, did not believe that the disease could be transmitted by healthy carriers. He based this assumption on the statement, made by Pfeiffer, that the influenza bacillus was only found in acute influenza cases. In the past few

years it has been abundantly shown, however, that the influenza bacillus can and does exist on the mucous membranes of healthy individuals.

The outbreak in an orphan asylum in New Haven has been previously described. There the probable source of the sharp outbreak of December 27th seemed to be the sister who, on convalescence, resumed her duties in the kitchen. There she inspected and handled the milk served to the children. This suggests the possibility of infection being propagated by convalescents and by food.

At present we do not know whether or not a patient remains infectious after the acute symptoms have subsided; we are ignorant as to whether a convalescent patient can transmit the disease; and we are not certain whether the organism found in healthy carriers is virulent or not. The information at hand strongly indicates that apparently healthy individuals may transmit the infection, but the wide distribution of the disease, with multiple possible sources of infection for each individual, and the relative insusceptibility of experimentally exposed individuals has made it impossible so far to answer these questions satisfactorily.

General Manner of Spread in Individual Localities.

Having discussed the mode of propagation of influenza among individuals we will follow the disease as it attacks one person after another in a community and study the epidemiologic picture, drawn no longer with the individual as a unit, but with the community as the unit.

We must here distinguish between a primary epidemic, the first wave of a progressing pandemic, and the secondary type in which may be grouped those large or small recurrences which light up for a period of one to three or more years after the primary wave.

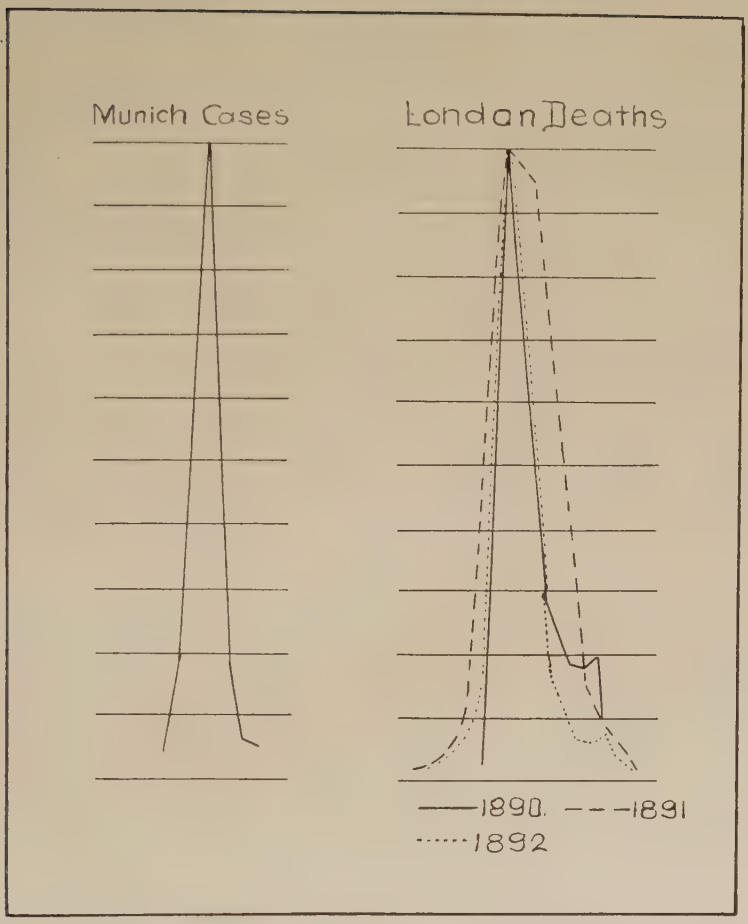
Primary type of epidemic.—One of the first important statistical studies on this subject was that of P. Friedrich who charted the influenza morbidity in Munich between the months of December, 1889, and February, 1890. Similar observations have been made by Parsons, Raats, Linroth, and H. Schmid, following the 1889 epidemic.

Between the occurrence of the first known case of influenza and the time of the first very definite increase in influenza incidence in a community, which interval may be termed the invasion period, there is as a rule two weeks. During this period, of course, more and more cases are occurring, but remain usually sufficiently isolated to attract no public notice. From this point the epidemic develops very rapidly

and reaches its peak, usually within two or at most three weeks. In another two or three weeks the incidence has fallen away nearly to normal. The epidemic period comprises from four to six weeks, or, including the invasion period, an entire duration of six to eight weeks. This is the picture produced in a community by a primary uncomplicated epidemic of influenza. Greenwood well describes the salient features of a primary epidemic as "first a rapid and quasi-symmetrical evolution, and second, a frequency closely concentrated around the maximum." In other words the duration is short, the rise to a peak rapid, and the subsequent fall equally rapid. He showed that in the July and August, 1918 epidemic in Great Britian nearly 80 per cent. of the total incidence in the localities studied was grouped within three weeks time. His curve corresponds so well with that of the Munich epidemic that he is able to superimpose them (Chart I). The rapid rise to a peak, almost explosive in character, more characteristic of this disease than of any other, is to be explained by the high degree of invasiveness of the organism, by the short period of incubation, by the fact that many of the sick continue at their work, thus spreading the disease, and by the non-immunity of large masses of people, together with the fact that the transmission of a respiratory infection is accomplished much more easily than is any other type of infection.

The author holds that the infrequency of immunity is a most important factor in the production of this type of outbreak. The mode of transmission of influenza is the same as that of other respiratory diseases. The infectivity is probably no greater than that of measles, although that indeed is relatively great. The means of transmission are presumably the same in each. Were we able to develop an immunity for influenza of as high degree and permanence as we possess against measles, pandemics of influenza would disappear. We wish to emphasize that the primary type of curve is a phenomenon not peculiar to influenza, but that under certain circumstances it may be found in other infectious diseases, and that it would be found more frequently in the other diseases if the immunity developed against them was of as short duration as it appears to be against influenza. If, for example, measles were to break out in a large group of individuals, none of whom had had the disease, the type of curve would be the same. We will produce evidence supporting our theory under another subject. Of course, other factors such as short incubation period and unusual opportunities for spread through mildly ill individuals play a not unimportant role.

CHART 1



The curves of incidence of influenza in Munich, and of deaths in London during the 1889 and subsequent epidemics. (*Greenwood.*)

Secondary type of epidemic.—There is a decided difference between the curve of a primary wave as it appears in the onward rush of a new pandemic and that of a secondary wave occurring at a greater or less interval following the primary spread. A secondary epidemic affects, according to Greenwood, a relatively small proportion of the population, is slower in reaching its maximum, and thereafter declines slowly and irregularly, more slowly than it increases. The distribution of the curve is less symmetrical and there is less concentration around the maximum. A secondary epidemic may be characterized by a much higher fatality than a primary one.

We believe that the configuration of a secondary type of wave is due chiefly although not entirely to a certain degree of residual immunity in a large number of individuals remaining from the first spread. There is a striking similarity between Chart I and Chart XXVIII, the latter showing the measles incidence in epidemics among rural or chiefly non-immune troops in the United States army. Chart XXIX shows a similar epidemic among urban or chiefly immune individuals. Here the curves correspond more to those of a secondary type of influenza epidemic. Thus we see that, in the absence of immunity, other infectious diseases may produce the primary type of curve, and that this curve is not a feature of influenza alone.

A striking difference between the two types of waves of influenza is the uniformity and relative constancy of the primary type as contrasted to the great variation in the secondary type. The story of the first spread of influenza in one community is usually similar to that of its spread in any other community. Certain exceptions will be alluded to later. But in the case of recurrent epidemics we may find them more severe or much milder; we may find that they attack a large number of individuals or a very few; we may even find an entire absence of recurrent epidemics in certain communities. The primary curves are relatively uniform; the secondary curves are variable.

Between 1889 and 1894 in England there were four epidemics. The first was primary, symmetrical, and lasted between December and February, 1889–90. The second was asymmetrical and much more fatal in the localities studied by Greenwood. It occurred in the spring and summer of 1891. There was a third epidemic in the autumn and winter of 1891–92 and a fourth occurred from November, 1893 to January, 1894. The third epidemic, according to Greenwood, showed some tendency to revert to the primary type in respect to symmetry, while the fatality rate partook of the character of a secondary epidemic.

Creighton writes: "That which chiefly distinguishes the influenza of the end of the nineteenth century from all other invasions of the disease is the revival of the epidemic in three successive seasons, the first recurrence having been more fatal than the original outbreak, and the second recurrence more fatal (in London at least) than the first. The closest scrutiny of the old records, including the series of weekly bills of mortality issued by the parish clerks of London for nearly two hundred years, discovers no such recurrences of influenza on the great scale in successive seasons."

Greenwood, who has studied this subject in great detail in England, discusses Creighton's remarks as follows: "He would be a bold man who challenged the accuracy of Creighton upon a point of historical scholarship, and I have only to suggest that there are faint indications of increased mortality in years following primary epidemics of influenza prior to the nineteenth century. Thus 1675 was a year of primary epidemic influenza, fully described in Sydenham's Observationes Medicae.

"The nature of the succeeding constitutions is not clear, but the deaths 'within the bills' for 1676 were considerably more numerous than in 1675, although smallpox, fever and 'griping of the guts' were noticeably less fatal.

"In the English Responsoria (1, 54) the epidemic constitution of 1679 is described as a recurrence of that of 1675—that is, as having the features of primary epidemic influenza. In the five following years intermittents prevailed, and in one (1684) the mortality much exceeded that of 1679, although the deaths from smallpox were fewer. Again, a hundred years later, in 1782, there was a famous summer epidemic of influenza in London which gave rise to much discussion. The London mortalities in 1782 and 1783 were, however, almost equal, when the smallpox deaths (which were nearly three times as numerous in 1783 as in 1782) are subtracted from the total mortality of each year.

"Whether these vague indications are sufficient to permit of our thinking that the epidemic constitution of 1889–94 was not entirely unprecedented is disputable. But the contrast of the latter period with the preceding single epidemic of 1847–48 is striking; that was a primary epidemic without important sequelæ.

"We have now to consider whether our experience this year is concordant with that of the early nineties, a reversion to the earlier type, or a new phenomenon."

After comparing the 1889 curves with those for the July, 1918, outbreak in England, Greenwood concludes: "I believe that the evi-

dence just presented establishes a substantial identity between the summer outbreak of 1918 and the primary wave of 1889–90. We do not need to appeal to any new factor arising out of the war to account for it.

"I next consider the secondary epidemic which we are now experiencing (October, 1918). Evidently our knowledge of the events in 1891 would lead us to feel no surprise at the emergence of a secondary wave, although we could not be sure that the precedent of 1847 would not be followed.

"The summer epidemic of 1918 in the Royal Air Force included nearly 80 per cent. of the total incidence within the three weeks containing the maximum, and the Munich epidemic included just over 80 per cent. within the same limits. Now if the current epidemic has reached its maximum, not more than 65 per cent. of the incidence will probably be so concentrated, and the duration will therefore be longer than in the summer; if, as suggested by the ratio of the last two ordinates, the maximum is not yet attained, then the quota of the three first weeks is likely to be still smaller and the complete duration still longer.

"The diagram of factory sickness leads to the same inference, which is that, from the standpoint of prevalence, the present is a typical secondary epidemic, congruent with that of 1891.

"It appears, then, that the origin of the summer epidemic must be explained upon such epidemiological principles as will account for the primary wave of 1889–90, that the current outbreak is in pari materia with that of 1891, its excessive mortality being mainly due to the accident of season, aided by the special circumstances of overcrowding and fuel shortage which are due to the war. In a word, this is not essentially a war epidemic."

Wutzdorff found that in some towns, particularly in North Germany, the 1891–1892 wave was almost as extensive as that of 1889–90 had been in other places, but that in general the morbidity in Germany was much lower. He bases these conclusions on a study of the extent of crowding in the hospitals in the two years, on statistics of government physicians, etc.

In Europe the recurrent epidemics of 1891 increased as a rule very gradually, developed slowly, reached their high point frequently after many weeks, and as gradually decreased. The epidemic duration in the winter of 1891–92 lasted four or five months. The morbidity in spite of the longer duration was decidedly less. This is very different from the explosive appearance of 1889 when the peak was reached

in fourteen days and the whole epidemic had been completed in six to eight weeks. There were some exceptions to this rule, as in Yorkshire, England, where the epidemic broke out suddenly between the 11th and 13th of April, 1891, had reached its peak after ten days, and for another twenty days declined. Especially interesting was Sheffield, where the first spread began gradually and ran a slow course, while the second epidemic of 1891 began explosively, lasted a short time and declined rapidly, but showed a significantly greater mortality than that of 1889.

The experiences in various communities in the United States have been not unlike those described for European cities. Abbott in describing the successive epidemics in Massachusetts remarked that the 1889–90 spread manifested itself by a sudden rise in the mortality from influenza and pneumonia, beginning about December 20th and culminating in the middle week of January, thereafter falling off quite suddenly in February to about the usual rate for these diseases. The second epidemic two years later began with a more gradual rise in October and November and then increased sharply in December, continued for nearly three weeks at its maximum in January, and declined nearly as sharply as in the previous epidemic two years before.

Winslow and Rogers who have studied the 1918 epidemic as it affected the various towns of Connecticut observed that the outbreak in a given community generally occupied a period of from six to eight weeks, and was steep and abrupt in communities which were badly hit, flatter and more gently sloping in those which escaped lightly. Also the outbreak was more severe in communities receiving the infection early than in those later affected.

Mortality curves.—Pearl has studied the epidemic constitution of influenza in forty-two of the large cities of the United States. He has plotted the annual death rate per 1,000 population from all causes in each week, from the week ended July 6, 1918, up to January 1, 1919, and observed a very distinct difference in the type of curve for deaths from all causes during the epidemic period in the various cities. These differences have been chiefly in respect to the severity and suddenness with which they were attacked. Thus Albany, Boston, Baltimore, Dayton and Philadelphia show an initial explosive outbreak of great force, while Atlanta, Indianapolis, Grand Rapids, Milwaukee and Minneapolis exhibit a much slower and milder increase of the mortality rate. In Albany and Baltimore the curve of the first epidemic outbreak rises to a peak and declines at about the same rate. In Cleve-

land and St. Paul, on the other hand, the rate of ascent to the peak is very rapid, while the decline is slow and long drawn out.

Some of the cities, such as Albany, show but a single well defined peak in the mortality curve. Others, such as Boston, New Orleans and San Francisco show two peaks; while still others, like Louisville, show three well marked peaks.

Usually the first was the highest and the second and third were progressively lower. Milwaukee and St. Louis, on the other hand, showed second peaks higher than the first. The usual phenomenon, however, was a large first wave followed by smaller ones.

The highest, or maximum peak-rate of mortality during the epidemic varied greatly, from 31.6 per 1,000 in the case of Grand Rapids, to 158.3 per 1,000 in the case of Philadelphia.

The death rates which were of the most frequent occurrence were, generally speaking, rates below 70 per 1,000 per week.

The date of the week in which the maximum peak rate occurred was earliest in Boston and Cambridge, where it occurred October 5th, and latest in Grand Rapids, Milwaukee and St. Louis (December 14th). Thirty-one of the 40 cities studied had attained the peak rate of mortality prior to November 2d. In the case of Milwaukee and St. Louis the maximum peak was the second peak, whereas in Grand Rapids it was the first peak that was so late. Sixty-five per cent. of the 40 cities showed two distinct peaks in the mortality curve, while 15 per cent. had one peak, and 8 or 20 per cent. had three peaks.

"It appears clearly that there was a definite tendency for the two-peak cities to fall into two groups in respect of the time elapsing between first and second peaks. About a third of them had the second mortality peak around eight weeks after the first peak. The remaining two-thirds had the second peak, on the average, about thirteen weeks after the first. The three-peak curves had the second peak on an average 7.1 ± 0.3 weeks after the first, and the third peak on an average 13.1 ± 0.3 weeks after the second. The cycle in the epidemic waves would therefore appear to be nearly a multiple of seven weeks rather than the ten weeks tentatively deduced from the dates of peaks. There the process of averaging obscured the true relations."

Duration of explosive outbreak.—The range of the duration of the first outbreak of epidemic mortality is great, varying from five weeks in Richmond, Virginia, to twenty-three weeks in Atlanta, Georgia. Twenty of the cities, one half the total number, showed a duration of ten weeks or less, while in the other half the duration was eleven weeks

or more. The mean duration of epidemic mortality in the first the outbreak was 11.90 ± 0.55 weeks. The ascending limb of mortality rate was rapid in nearly all cities. The descending limb was usually slower. In 34 of the 40 cities it required four weeks or less time for the mortality rate to pass from normal to its epidemic peak. But in only half as many (17) of the cities did the rate come down from its peak to normal again in a period of four weeks or less. The mean time from normal mortality rate to peak was 3.90 ± 0.21 weeks. The mean time from peak mortality rate to normal was 8.00 ± 0.50 weeks. Thus it took about twice as many weeks for the mortality curve to come back from its peak to normal, as were required for the increase from normal to peak at the beginning of the explosion. This is on the average. The ascending limb occupied about a month and the descending limb two months.

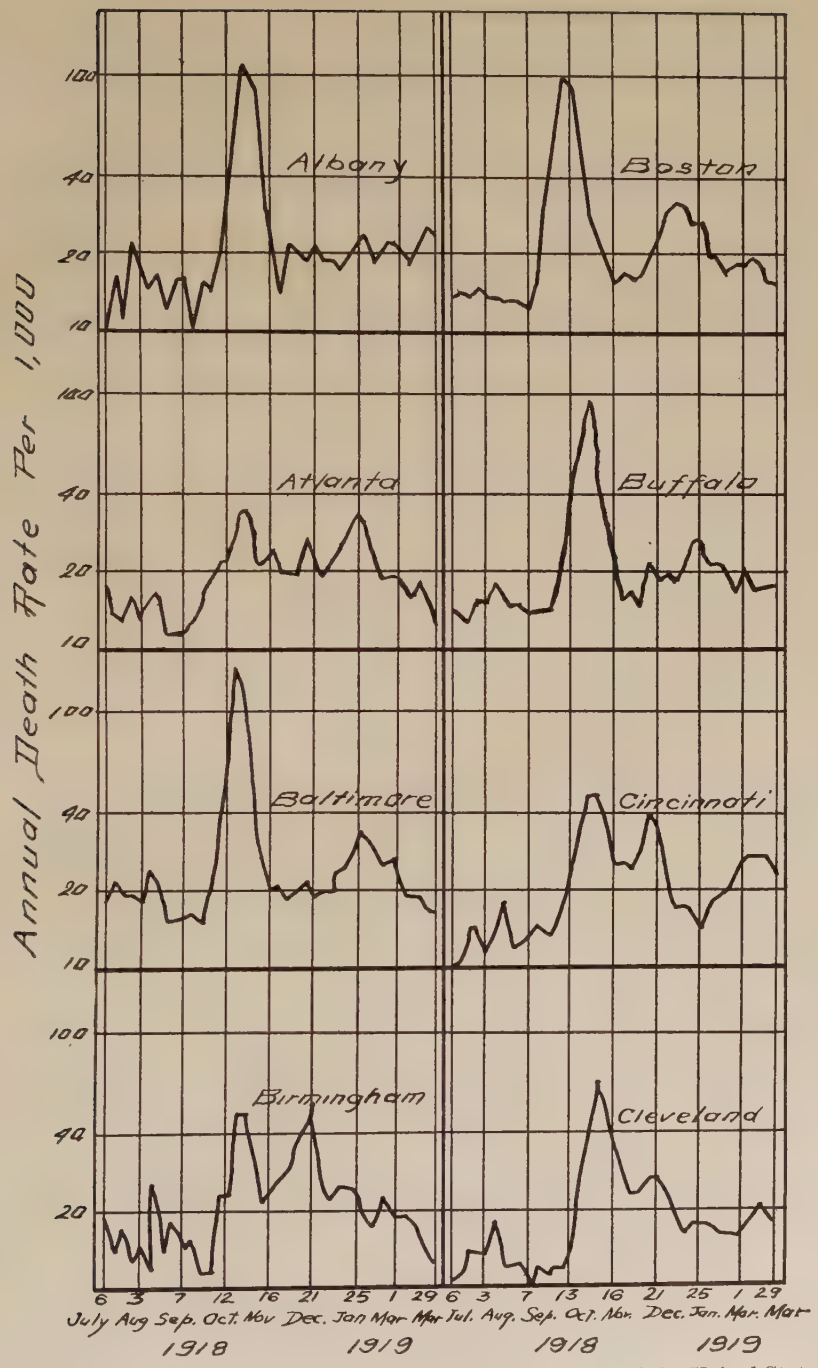
Pearl's curves which have been copied in this report (Charts II to VII) enable us to follow his conclusions. Pearl offers a partial explanation for the variations in the different cities. There can be no doubt but what many factors play a role in the causation of these variations, and it is to be regretted that up to the present no statistics for smaller, more homogeneous communities have as yet been reported which could be compared with Pearl's excellent work on the large cities of the country. Were his work supplemented by records from smaller towns in which the varying factors are less numerous, in which there is less occupational variation, additional conclusions could probably be reached. The unfortunate feature is that as a rule statistics from the smaller cities and towns are less reliable.

From a detailed mathematical study of influenza in 39 of our largest cities, done chiefly by the means of multiple correlation, with the hope of being able to explain the differences in the epidemic curves of weekly mortality in the various cities, Pearl concludes as follows:

"The general conclusion to which we come from an examination of the correlation data assembled to this point is that these four general demographic factors, density of population, geographical position, age distribution of population, and rate of recent growth in population, have practically nothing to do, either severally or collectively, with bringing about those differences between the several cities in respect to explosiveness of the outbreak of epidemic mortality in which we are interested. Significantly causal or differentiating factors must be sought elsewhere."

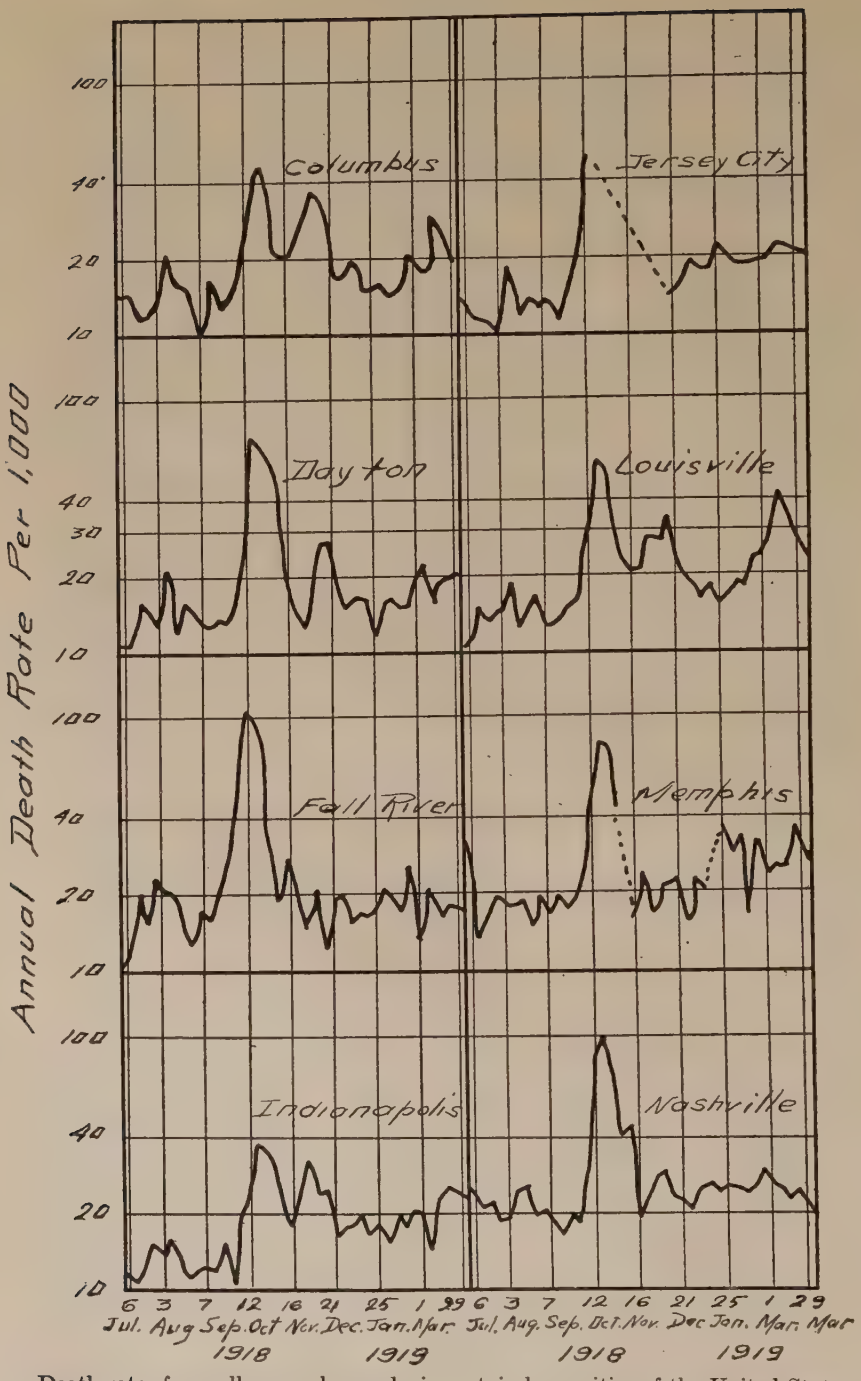
Concerning geographical position, he did find some slight relation-

CHART II.



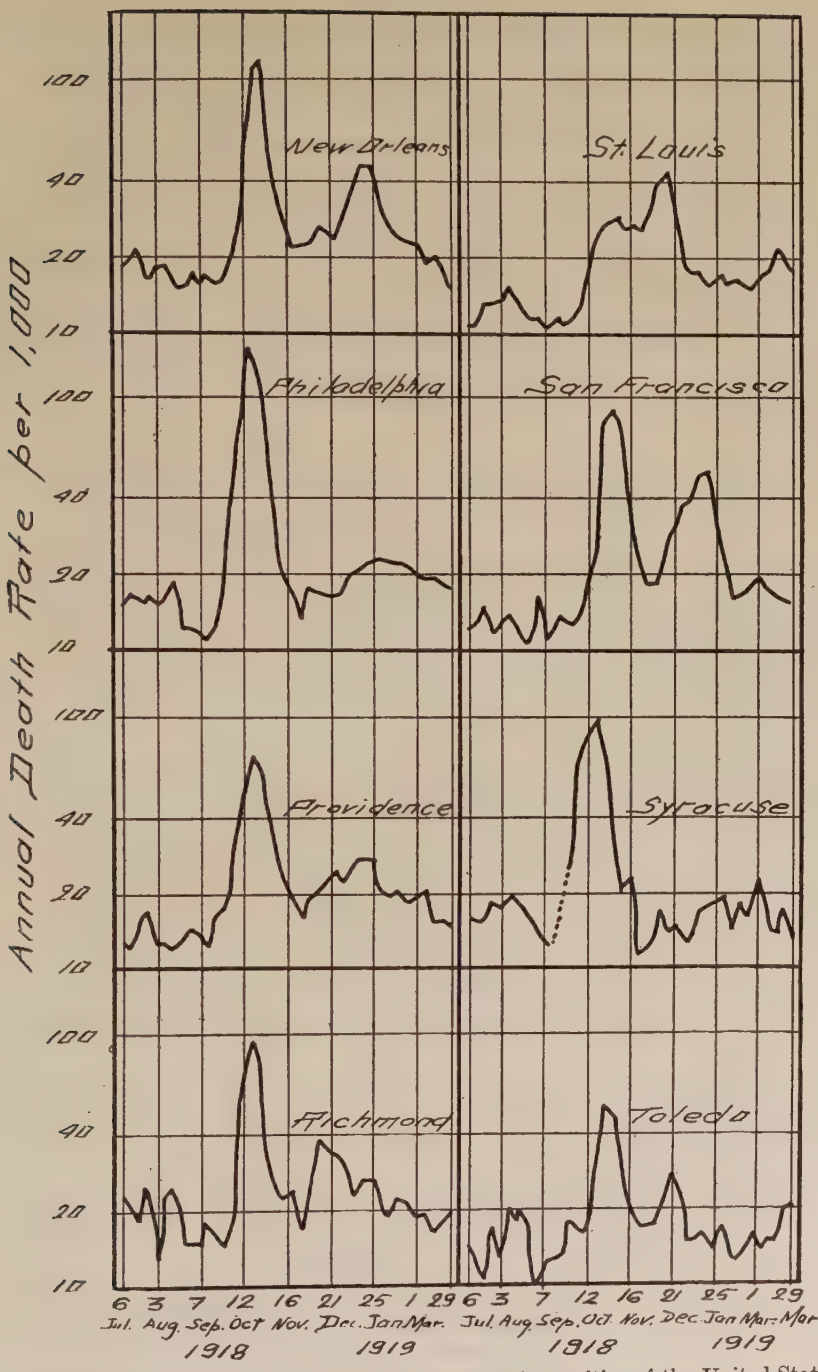
Death rates from all causes by weeks in certain large cities of the United States during the winter of 1918–19. (*Pearl.*)

CHART III.



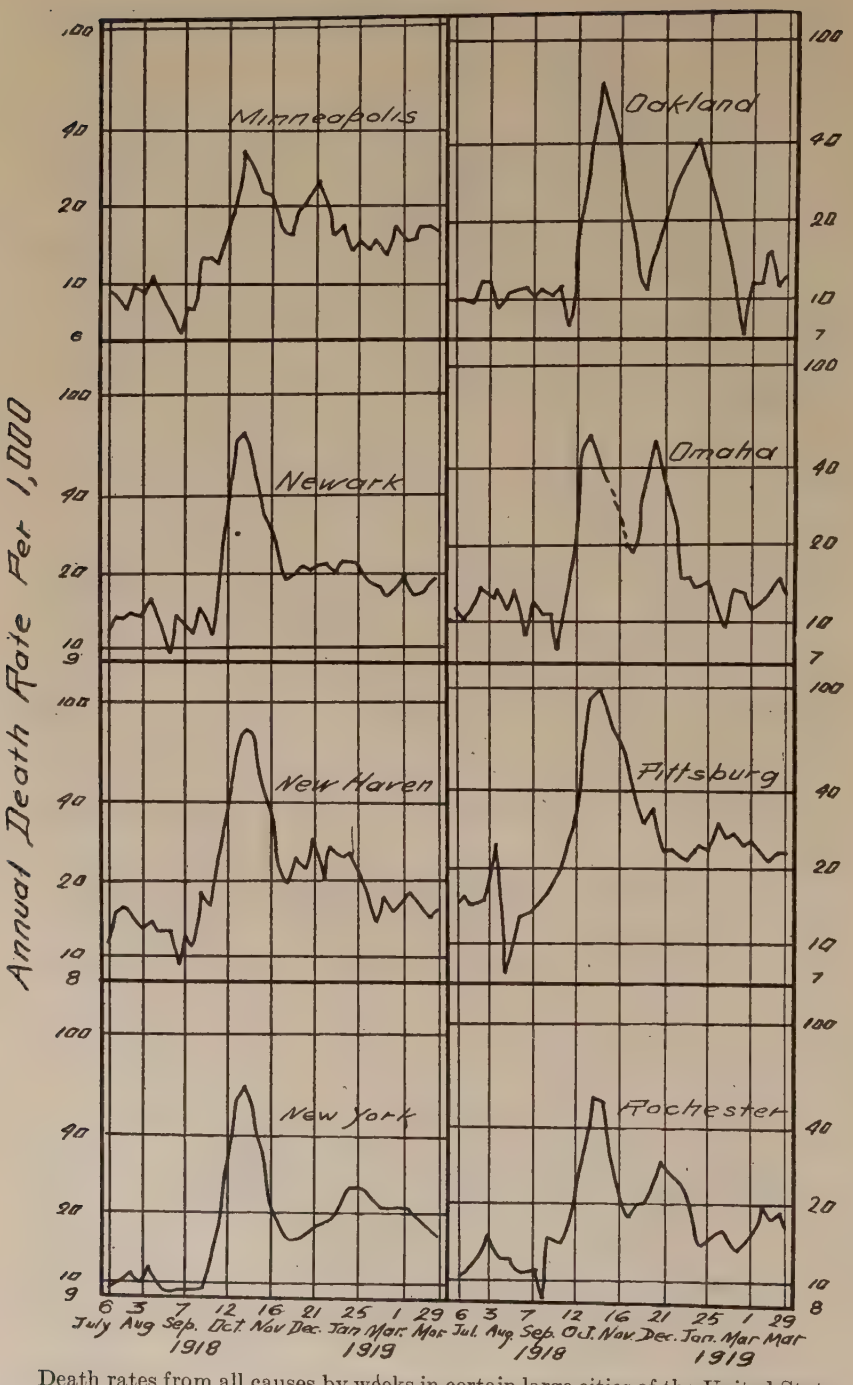
Death rates from all causes by weeks in certain large cities of the United States during the winter of 1918–19. (*Pearl.*)

CHART IV.



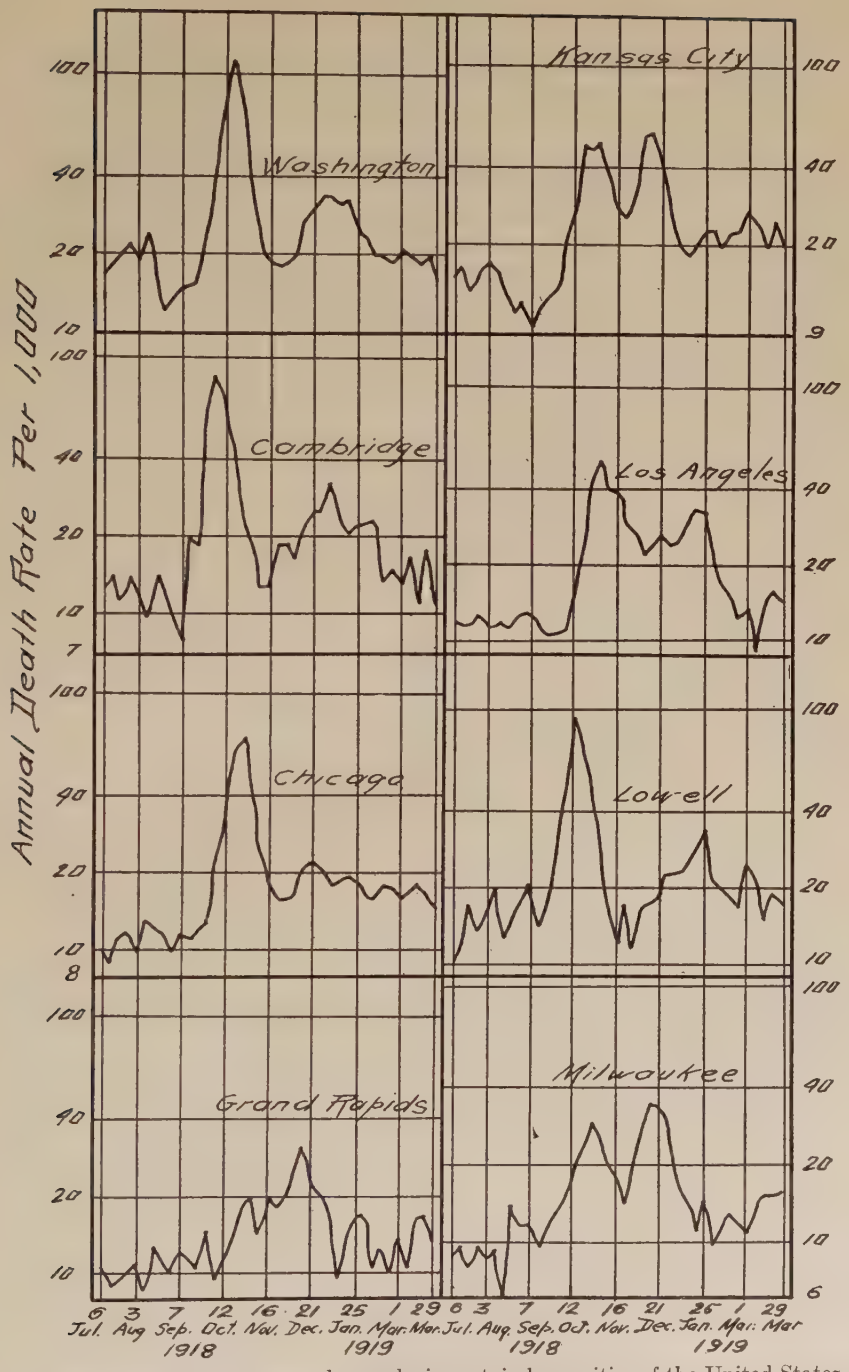
Death rates from all causes by weeks in certain large cities of the United States during the winter of 1918–19. (*Pearl.*)

CHART V.



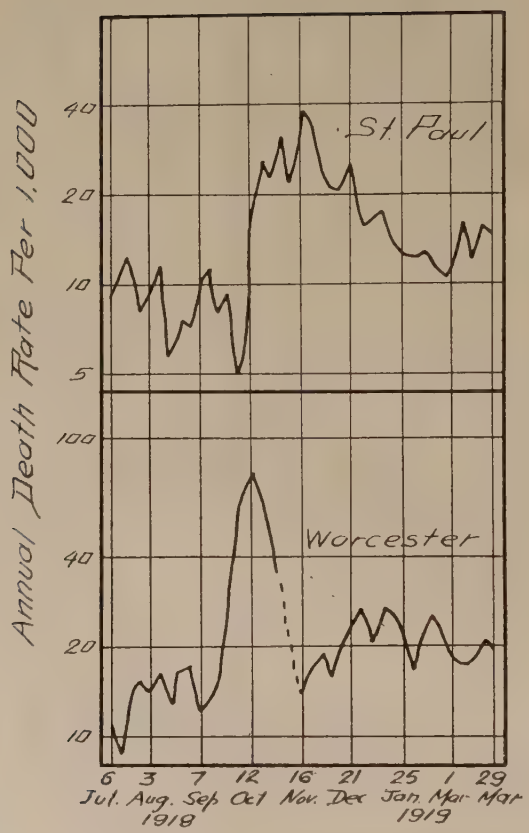
Death rates from all causes by weeks in certain large cities of the United States during the winter of 1918–19. (*Pearl.*)

CHART VI.



Death rates from all causes by weeks in certain large cities of the United States during the winter of 1918–19. (*Pearl.*)

CHART VII.



Death rates from all causes by weeks in certain large cities of the United States during the winter of 1918–19. (*Pearl.*)

ship with linear distance from the city of Boston, where the epidemic was supposed first to have begun in this country:

"This result means that the greater the linear distance of a city from Boston the less explosive did the outbreak of epidemic mortality in that city tend to be. This is in accord with the general epidemiological rule that the force of an epidemic tends to diminish as it spreads from its primary or initial focus. It must be noted, however, that the correlation coefficient in this case is not large. It is barely past the value where it may safely be regarded as statistically significant. This fact may probably be taken to mean that influenza does not follow the epidemiological law referred to with anything like such precision as do some other epidemic diseases, notably poliomyelitis."

These factors having been found to be of little value in his attempt to explain the varying curves in the 39 different cities, Pearl next correlated the explosiveness of the epidemic mortality with deaths from all causes, deaths from pulmonary tuberculosis, from organic heart disease, from acute nephritis and Bright's disease, from influenza, from pneumonia (all forms), from typhoid fever, from cancer and from measles, in the various cities.

"The outstanding fact which strikes one at once from this table is the high order of the correlation which exists between the explosiveness of the outbreak of epidemic mortality in these communities and the normal death rate from certain causes of death in the same communities. In the first four lines of the table the correlation coefficients range from about 6 to more than 10 times the probable errors. There can be no question as to the statistical significance of coefficients of such magnitude.

"The highest correlation coefficient of all is that on the first line of the table, for the correlation of epidemicity index with death rate from all causes. The existance of this high correlation at once indicates that an essential factor in determining the degree of explosiveness of the outbreak of epidemic influenza in a particular city was the normal mortality conditions prevailing in that city. In the group of communities here dealt with, those cities which had a relatively high normal death rate had also a relatively severe and explosive mortality from the influenza epidemic. Similarly, cities which normally have a low death rate had a relatively low, and not sharply explosive, increase in mortality during the epidemic.

"It will also be noted that the correlation in the next three lines of the table, namely those of pulmonary tuberculosis, so-called, organic diseases of the heart, and chronic nephritis and Bright's disease, are

of the same order of magnitude as that between the death rate from all causes and the explosiveness of the epidemic outbreak of influenza."

Pearl suggests that this correlation might arise because of differences in the constitution of populations in the different cities, or, that it was a factor of geographical position, such as the distance from the Atlantic seaboard; but that even after correction of the results for age distribution and geographical position, the net correlations were actually higher than were the gross uncorrected correlations.

"We may conclude that the most significant factor yet discovered in causing the observed wide variation amongst these 39 American cities in respect of the explosiveness of the outbreak of epidemic influenza mortality in the autumn of 1918 was the relative normal liability of the inhabitants of the several cities to die of one or another of the three great causes of death which primarily result from a functional breakdown of one of the three fundamental organ systems of the animal body, the lungs, the heart and the kidneys."

Winslow and Rogers studied the relation of the pneumonia death rate from 1901 to 1916 to the influenza death rate of 1918 in 40 large cities of the United States and found a distinct correlation. The cities which have been characterized by a high pneumonia rate in the past are precisely the cities which suffered most severaly in the 1918 outbreak. This is not due especially to virulent types of pneumonia organisms in certain sections of the country because they found this same high correlation between total death rates and influenza death rates, in the same cities.

They believe that these high correlations may be the result of weaknesses in the population due to high incidences of organic disease and tuberculosis in earlier years, or more probably that the correlation is an indirect one, due to the relation between each of the factors studied and one or more underlying conditions affecting both, such as age distribution of the population, race distribution, or social and economic conditions in the various cities studied. Or, finally, it may be that the high rate from tuberculosis and organic disease in 1916 was due to these latter factors, while the high incidence of influenza was due chiefly to proximity to the original focus of infection. None of these explanations are considered entirely satisfactory.

It is important to call attention to the fact that the American observers quoted have been studying the death rate from influenza as it is revealed in the increase of death rate from all causes, whereas Leichtenstern and Wutzdorff, and Greenwood, in his studies in the Royal Air Force have concerned themselves with *morbidity*. The

comparison of morbidity and mortality cannot be easily made as we will show when discussing these two subjects, so we cannot conclude that the work of Pearl and of Winslow and Rogers is at variance with the other work quoted. The mortality curves form another characteristic of the local spread of influenza in a community.

It is characteristic of influenza that the curve of deaths does not fall as rapidly as does the curve for influenza cases. Thus in morbidity curves we may expect to find a symmetrical curve for a primary epidemic, but the mortality is rarely if ever symmetrical, the curve rising rapidly and falling very much more slowly.

Morbidity curves in 1920 *recurrences.*—The curves of influenza incidence in the recurrence of 1920 have varied in different localities, but in certain communities where the record has been carefully reported the epidemic appears to be characterized by a symmetrical evolution and usually a lower death rate as compared with 1918. The curve of incidence in the State of Massachusetts in January, February and March, 1920, is symmetrical, if anything falling away more rapidly than it ascends, and the duration is at least ten weeks. The crest of the influenza wave in Massachusetts was reached on February 4th, 5th and 6th. The peak is recorded as being in the week of February 7th.

During the 1920 epidemic the author made a house to house canvass in six representative districts in the city of Boston covering a population of 10,000 individuals. The curve of incidence of influenza corresponds closely with the curves for the city and the state as a whole. The peak was reached in the same week, the week ending February 7th, the curve was symmetrical, and the duration of the entire epidemic was about the same. The morbidity rate for 1920, according to our influenza census, was but half of that for 1918 for the same population. The recurrent epidemic as we will show later was decidedly milder (see Chart XVIII).

In Detroit the 1920 epidemic reached its peak for morbidity on the 9th day, and that for mortality on the 16th. In 1918 the morbidity peak was not attained until the 15th day and the death peak on the 22d. The recurrent outbreak had nearly run its course within three weeks. The following comparison between the influenza incidence in 1918 and 1920 in Detroit is taken from a report by H. F. Vaughan, Commissioner of Health for that city. In it is shown a comparison of the total figures on the twenty-seventh day of each of the two epidemics:

A Comparison of the 1918 *and* 1920 *Epidemics of Influenza in Detroit. Statistics Made to Include Through the Twenty-seventh Day of Each Epidemic.*

	Influenza cases	Deaths from influenza and pneumonia	Normal influenza and pneumonia deaths for this season	Excess influenza and pneumonia deaths above normal
1920 (Jan.–Feb.).....	11,202	1,642	197	1,445
1918 (Oct.–Nov.).....	16,423	1,286	124	1,162

There had been fewer cases reported on the twenty-seventh day of the 1920 epidemic, but these had resulted in a greater number of deaths. On this day the recurrent epidemic had run its course, while the 1918 one was still in full swing. On the twenty-seventh day of 1918 there were 137 influenza cases reported and 49 deaths. On this day in 1920 there were but 24 cases and 34 deaths. Thus the second outbreak was of shorter duration, but was more deadly while it lasted.

Seven weeks of the 1920 epidemic in Detroit killed 0.20 per cent. of the population, two out of every one thousand people. A similar period at the beginning of the epidemic of 1918 witnessed the death of 0.17 per cent. of the population. This was a smaller number, but the epidemic at this time had not completed its course, and continued to be more or less prevalent for twenty-one weeks, resulting finally in the death of 0.28 per cent. of the population. The recurrent epidemic was more highly fatal, but, being of shorter duration, Detroit actually suffered less from it.

Spread in Countries and Continents.

The spread of influenza is usually not limited to a single community. Almost invariably it will travel on to another locality, carried thither by human intercourse, and will there build again a local epidemiologic picture more or less modified by changes in the environment and changes in the virulence of the virus itself.

Spread in primary waves.—Reference to the table of epidemics in history will show that in many of the epidemics and in most of the widespread epidemics and pandemics there appears to have been a definite, clearcut, direction of spread from one locality to others. In the recent literature there has appeared considerable discussion concerning the site of origin, the endemic focus of pandemic influenza. Briefly the question raised is as to whether there are single or multiple foci. We will for the time ignore this perplexing question. In either case, after the influenza virus has once attained such communicability

as to produce a pandemic it does follow a direct course over countries and continents. This may be followed in resumé in our table.

The disease does not at any time spread more rapidly than the available speed of human communication between the areas affected. If influenza does appear simultaneously in two widely separated communities without having been brought there from a common source it must be that it arose spontaneously from simultaneous increase in virulence of the virus in those localities.

Influenza was prevalent in Turkestan, Western Asia, in May of 1889. It spread first to Tomsk in Siberia and did not appear in Petrograd until the end of October. By the middle of November it had reached Berlin and Paris, and one month later it was epidemic in New York and Boston. Four months had been required for the disease to reach Petrograd from Bokhara in Turkestan, while within two months thereafter it had traveled from Russia to the United States. In both cases the rapidity of spread corresponded to the rapidity of the means of communication of the locality; the caravan in Turkestan and the transatlantic liner to America. North America was widely infected in January of 1890. So, also, Honolulu, Mexico, Hong Kong, Japan. Ceylon first experienced the epidemic early in February, India at the end of the month, Borneo and Australia on the first of March, Mandalay towards the first of May, China and Iceland in July, Central Africa in August and Abyssinia in November of 1890.

It should be noted that influenza was reported to have been prevalent in Greenland at about the same time that it was in Bokhara. There appears to have been no relationship between these two outbreaks.

The spread of the pandemic may be followed also by recording the period of greatest mortality in the various cities. This period at Stockholm followed that at Petrograd by three weeks, and that of Berlin by another week. The period for Paris was a week later than for Berlin, that for London another week later, and that for Dublin three weeks later than that for London. The week of highest mortality in Dublin was later than that for New York or Boston.

The earlier epidemics progressed more slowly. That of 1762 prevailed in Germany in February, in London in April, in France in July, and in America in October. In 1782 it attacked London in May, Exeter two weeks later and Edinburgh early in June. In 1830–1832 the spread from Moscow and Petrograd through Germany required no less than eight months to cover the latter country.

In 1872 the time required for spread from Leipzig to Amsterdam

was eighteen days, the same time that was required for a merchant in the latter town to reach Leipzig.

There are many instances on record in which influenza has passed by small towns in its onward course to attack a larger city and only at some later date has the small town, not on the main line of communication, been affected. Not only is the speed of transportation between two communities of importance, but also the volume of the transportation undoubtedly plays a part in the rapidity of development in a second locality. When the disease is carried by a vessel the first places to be attacked are the seaports and the coast towns, be the land a continent or an island. From there it spreads inland either rapidly or slowly according to the transportation facilities. Formerly the question was raised whether influenza spread in continuous lines or radiated in circles. Naturally it follows the direct lines of communication, most of which are radially distributed around large centers.

Leichtenstern calls attention to the fact that in the 1898 epidemic, as in the previous one, the general direction of spread was from East to West across Europe. This was also true of the epidemics of 1729, 1732, 1742, 1781, 1788, 1799, 1833, and 1889.

There have been in Europe two general routes followed by pandemics, a Northern one through Russia and following the lines of travel into Germany and through the countries of Europe; and a Southern path coming from Asia, through Constantinople, and entering Europe from the South, particularly Italy. With the latter, after reaching Europe, the spread is northerly; with the former it is southerly, and usually Spain was the country last infected.

In the United States as well, pandemic influenza usually has spread from East to West, entering the country at or near New York or Boston, and spreading West and South. This was true in the autumn epidemic of 1918.

Spread in recurrences.—As a rule the manner of spread of a secondary epidemic following the primary pandemic wave is quite different. At a longer or shorter interval following the first spread the disease breaks out anew in one locality or another, sometimes simultaneously in widely separated districts. Sometimes we can distinguish a direction of spread in the relatively small community affected, it frequently being observed that the disease will start up in a large city which has experienced the illness during the first pandemic, and from there will spread to small nearby localities which may have remained free until that time. Again, any clear-cut direction of spread may be entirely

lacking. It is rare indeed that an epidemic following another by a short interval will follow a definite line over an entire country or continent. Such an example is, however, to be found in the epidemic of 1833, which traveled over Europe from Russia, spreading to the west and the south and following practically the identical path that it had taken in 1830. Even so it was not as widespread, for while the epidemic of 1830 had covered the entire earth, America appears to have escaped the second epidemic.

These disseminated and independent outbreaks are believed to arise from endemic foci in which the virus has been deposited during the progress of its first spread and in which the germ has survived until it has acquired once again exalted virulence.

Usually these endemic outbreaks show in their local configuration, a secondary type of wave. That this is not always the case we have already indicated. The epidemic of 1732–1733 was a recurrence of that of 1729–1730. The epidemic of 1782 had as its source the epidemic of the years 1780–1781. The epidemic of 1788 recurred until 1800, and was quite possibly associated with those of 1802, 1803 and 1805–1806. That of 1830 recurred in 1831–1832. Next we have in 1833 the true pandemic originating in Russia. Recurrences of the epidemic of 1836–1837 were found in 1838 and in 1841. Those spreads which occurred in 1847 and 1848 found successors in the year 1851. In 1890 the influenza outbreaks were as a rule single or isolated and occurred in only a few places of Europe, particularly in Lisbon, Nürnberg, Paris, Copenhagen, Edinburgh, Riga, London, etc. It is reported that there was an unusually severe local outbreak in Japan in August, 1890. In 1891 no general direction of spread was manifested, yet in heavily populated areas, or states rich in lines of communication, especially those of Europe and North America, one could frequently trace some definite direction followed by the disease within these relatively small territories.

A. Netter made the following observation at that time: "La Grippe a fait des explosions simultanées ou successives, et on n'a pu en aucune facon subordonner ces differents foyers comme cela avait été possible en 1889–90. Il parait y avoir eu des reveils de l'épidémie sur divers points."

Leichtenstern describes the subsequent spread of the disease: "The transfer of the disease by ships which played such an important role in the first epidemic appeared to be insignificant in 1891, in spite of the fact that influenza was present in many of the English colonies. The third real epidemic spread of influenza was a true pandemic which

began in the autumn (October) of 1891 and lasted through the whole winter until the spring of 1892. It involved all of Europe and North America and spread to all other lands, but here again the geographic distribution followed no rule. There was no spread of influenza from a central point, no continuous spread following lines of communication, and there was no longer an early predominance in the cities lying on the lines of communication or in the larger cities and commercial centers, as had been the case in the first epidemic. In England in 1891 the first outbreaks occurred frequently in country districts. The epidemic raged nearly four months in the northern part before it finally reached London in May. The same was true of Australia.

"One peculiarity of the recurrent epidemic lay in the much more contagious character of the disease and the remarkably greater mortality. In Sheffield the mortality in the recurrent epidemic was greater than in the pandemic, even though the epidemic picture was that of a primary wave."

By way of summary of our knowledge of the primary and secondary spread in general up to the epidemic of 1918, we may enumerate the more important characteristics:

1. Occurrence of true pandemics at wide intervals, primarily intervals of several decades.

2. Indefinite knowledge and conflicting evidence regarding site and manner of origin.

3. Apparent transmission chiefly or entirely through human intercourse.

4. Rapid spread over all countries, the rapidity roughly paralleling the speed of human travel.

5. Rapid evolution of the disease in the communities where outbreaks occur, with nearly equally rapid subsidence after several weeks' duration.

6. Apparent lack of dependance on differences of wind or weather, seasons or climate.

7. Generally low mortality in contrast to enormous morbidity. Variation in the incidence of disastrous secondary infections.

8. Tendency to successive recurrences at short intervals.

SECTION II.

Influenza Epidemics Since 1893.

In this section of our report we will describe with as great accuracy as our sources of information will permit, and in as great detail as space will allow the events which have led up to the epidemics of 1918–20 and the various phases of the epidemics themselves. Points of similarity with previous epidemics will be made obvious; the differences, when of significance, will be described and studied in detail.

Occurrence Since 1893.

Attempts even today to determine when and where influenza has prevailed in the world since the great pandemic of the last century are met with great difficulties. There are several reasons for this, chief among which is the absence of definite characteristics by which the disease may be recognized. The isolated solitary case baffles positive diagnosis. Nearly every year there are reports in the literature of small outbreaks in institutions or communities in which the clinical picture is that of epidemic influenza. As a rule the conclusion has been in these cases that because the bacteriologic findings did not show a predominance of Pfeiffer's bacillus the epidemic was not true influenza. This is particularly true in the outbreaks in which the streptococcus predominated. Today our views concerning the bacteriology have changed distinctly, and I believe it is safe to say that the predominance of a streptococcus in a local epidemic in no way rules out influenza, and that the only criteria by which we may judge are the clinical picture and the evidence of high infectivity, together with the epidemiologic characteristics of the local outbreak.

Period 1893–1918.—A review of the medical literature between 1889 and 1918 gives one a certain impression which may be summarized as follows: Between 1890 and 1900 the disease was in general more highly prevalent in most localities than at any time during the preceding thirty years. At no time during this decade did the annual death rate from influenza in England and Wales fall to anywhere near the figures that had prevailed consistently between 1860 and 1889. Between 1900 and 1915 there was a gradual diminution, but still not to the extent that had prevailed previous to 1889. Since 1915 there appears to have been a gradual increase. During the entire period there has been difficulty in distinguishing between the disease in

question and other respiratory tract infections, particularly coryza, sore throat, tonsillitis, and bronchitis. Many of the local epidemics which appear probably to have been true influenza have had associated with them a high incidence of sore throats. We describe this as sore throat, rather than tonsillitis, because the clinician remarks that although the throat is sore there is little if any demonstrable inflammation of the tonsils.

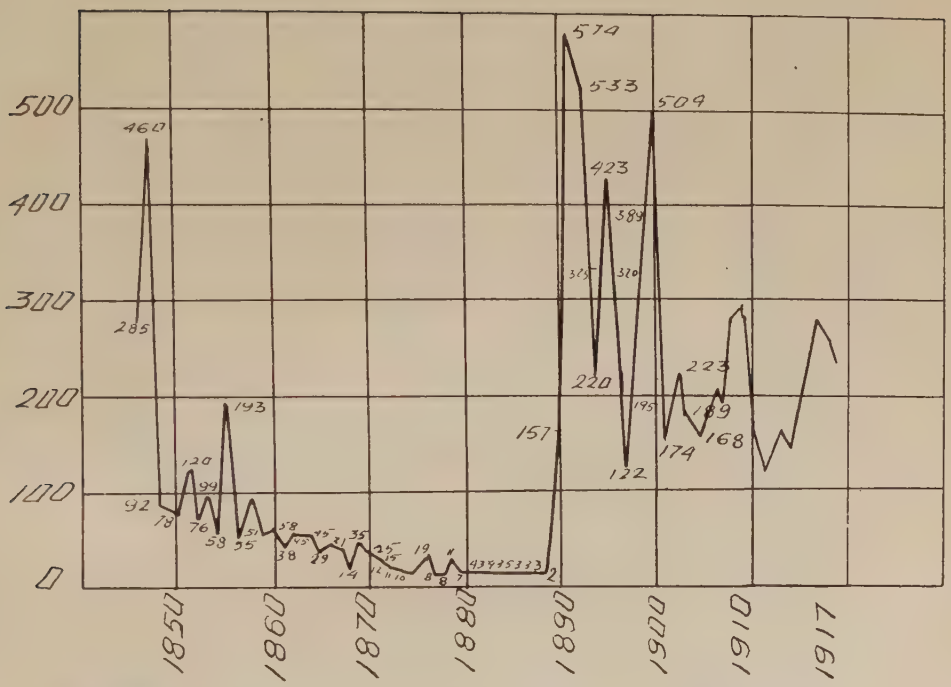
Chart VIII published by Sir Arthur Newsholme, showing the death rate per million of population from influenza in England and Wales gives some idea of the prevalence of the disease in the first part of the interpandemic period in those countries. It should be remarked that the record is for deaths from influenza only.

For records in this country it is convenient to refer to the death rate in the State of Massachusetts; first, because the records in that State have been carefully kept for a long period; and second, because influenza has been carefully studied in this State during both epidemics by two most competent epidemiologists. For the period preceding 1889 we quote herewith from Abbott:

"For the past 45 years or more, or during the period of registration which began with the year 1842, no epidemic of influenza has prevailed within the State to such an extent as to have manifested itself in any serious manner in the annual lists of deaths. An examination of the registration reports for each year since 1842 shows that in no year were recorded more than 100 deaths from this cause; the highest number from influenza in a single year (92) occurred in 1857, and the least number (8) in 1884. The average annual number of deaths from this cause reported in the State for the period 1842 to 1888 was 38. The average number during the first half of this period was greater than that of the last half, especially when considered with reference to the increase of population. From these statistics of non-epidemic influenza between the years 1842 and 1888 it appears that its greatest prevalence, or rather the years in which the mortality from this cause was greatest, were also years of unusual mortality from pneumonia, and in some instances from bronchitis."

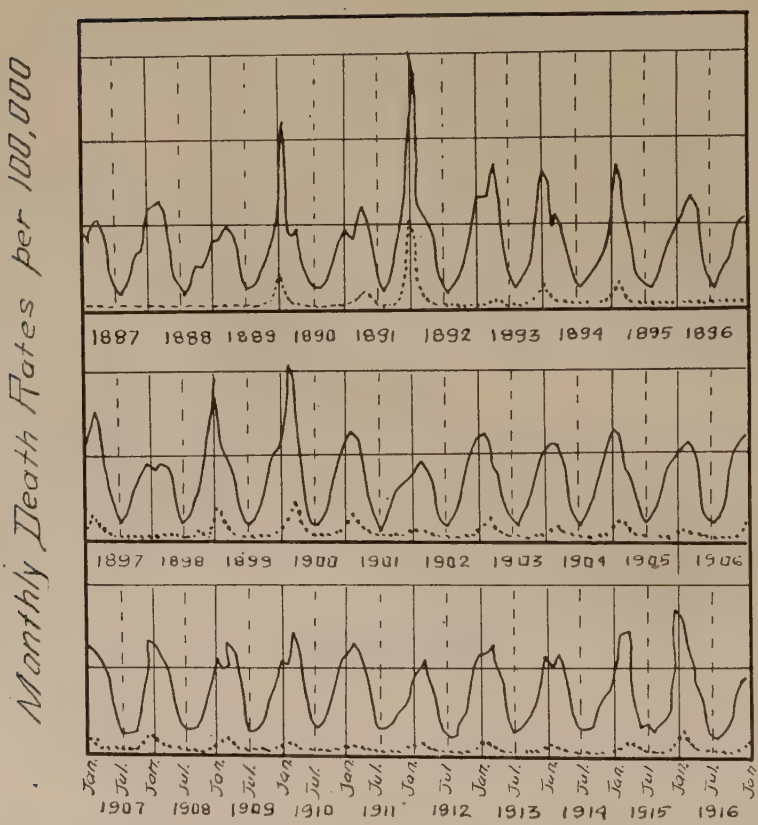
Frost has charted the death rate per 100,000 from influenza and from all forms of pneumonia in Massachusetts by month, from 1887 to 1916. From it he concludes that the epidemic of 1889–1892 developed in three distinct phases, the first culminating in January, 1890, the second in April and May, 1891, and the third in January, 1892. The mortality was higher in 1891 than in 1890, and still higher in 1892, while in 1893, although there was no distinct epidemic, the

CHART VIII.



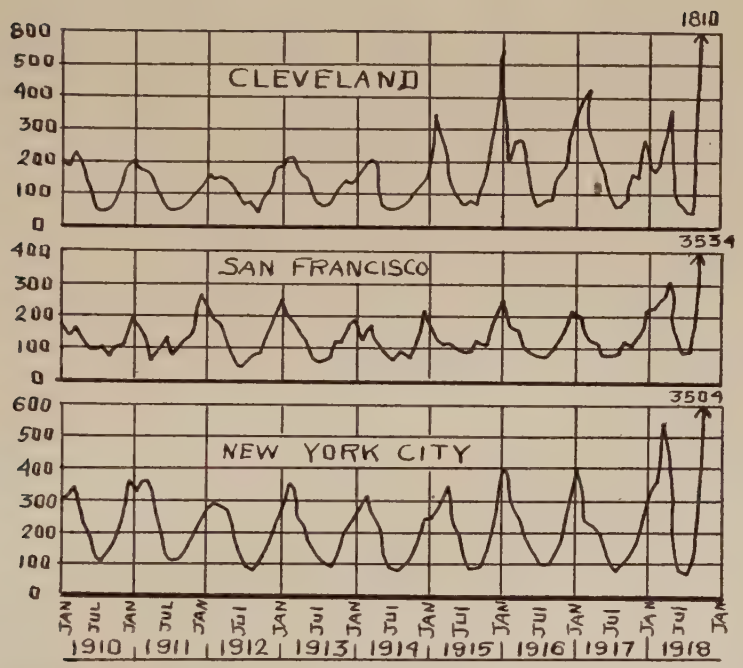
Death rates per million from influenza in England and Wales from 1845 to 1917. (*Newsholme.*)

CHART IX.



Monthly death rates per 100,000 from influenza and from pneumonia in Massachusetts from 1887 to 1916. (*Frost.*)

CHART X.



Monthly death rates per 100,000 from influenza and pneumonia in three cities of the United States from 1910 to 1918, inclusive. (*Frost.*)

pneumonia mortality for the year was even higher than that of 1892. Frost remarks that this corresponds to the experience in England, and that it apparently represents the general experience in other countries (see charts IX and X).

In the absence of comparable statistics for Massachusetts in 1917 and 1918, Frost has studied for those years certain other localities, particularly Cleveland, San Francisco and New York City. The mortality in all of these places, as well as in Massachusetts, was fairly regular from 1910 to 1915, but in December of the latter year and January of 1916 there occurred in New York and Cleveland a sudden sharp rise in mortality. This was not shown distinctly in the San Francisco curve, but it was a rise which was almost universal and synchronous over the entire registration area. It is of interest as indicating the operation of some definite and widespread factor, and suggesting in this group of diseases an epidemic tendency which is perhaps, as Frost remarks, not sufficiently appreciated. In January of 1916 he found that influenza was reported to be epidemic in twenty-two states, including all sections of the country. The epidemic was very mild. In the early spring of 1918 there was another sharp rise, which we shall discuss in greater detail later.

Increase in 1900–1901.—Reference to Frost's chart for Massachusetts shows that there was also a rise in the curve around 1900. At this time influenza was quite widely disseminated. Early in 1901 the Marine Hospital Service made a canvass of all the states and several foreign countries to determine the epidemic prevalence of influenza. The results of the canvass were published in the Public Health Reports. The records lack the detail, particularly in the description of clinical symptoms, that is desirable in arriving at an identification, but the universal agreement from all individuals reporting, in the comparatively high morbidity and remarkably low mortality, together with the widespread distribution, and the duration of the local epidemic leaves little doubt as to the identity.

Influenza was reported present in October of 1900 in Los Angeles, Milwaukee and New Orleans. In November it became prevalent in Toledo and Cincinnati and in New York City. In December the disease was present in Chicago, Albany Philadelphia, San Francisco, Denver, Baltimore, Grand Rapids, Columbus, O., Portland, Me., Detroit, Albuquerque and Omaha. In January it was reported in New Haven, Boston, Washington, D. C., Indianapolis, Louisville, Ky., Wilmington, Del., Portland, Ore., and Juneau, Alaska.

Although the disease was mild, in some localities a high proportion

of the population was attacked. Thus in New Haven it was estimated that 10 per cent. developed the disease, and in Los Angeles 20 per cent., while in Wilmington, 40,000 were estimated to have become ill. In certain small towns in Texas the incidence was especially high. In Pittsburgh, Texas, ten per cent; Laredo, 15 to 20 per cent.; Hearne, 50 per cent.; and El Paso, 50 per cent. were attacked. The duration of the epidemic in most localities was from four to six weeks.

Thus we see that in October, November and December of 1900 and January of 1901 there was a widespread epidemic affecting all parts of the United States. Many additional records in the Public Health Reports coming from small towns have not been included in this summary.

At the same time an attempt was made to determine the prevalence in foreign countries and letters were sent to the various United States Consulates. It was discovered that the disease was mildly epidemic in Denmark in October, in Berlin in November, in Cuba, British Columbia, Ontario, Egypt, Paris, Mexico and the West Indies in December; in Flanders, Porto Rico, Honolulu, in January of 1901; in Malta in February, 1901; and in London and Ireland in March of that year. The following countries reported that they had no influenza at the time: Windward Islands, Jamaica, Bahamas, Brazil, India, Colombia, Costa Rica, Ecuador, Honduras, Persia, Philippine Islands, Spain, Switzerland. The disease was reported as being not of epidemic prevalence in the following localities: Marseilles, Paris, Bremen, Hamburg, Mainz, Stuttgart, Bristol, London, Liverpool, England as a whole, Scotland, Amsterdam, Naples, Constantinople.

Reports from Switzerland and from Brazil stated that there had been no influenza since the pandemic period 1889–1893. The death rate per 100,000 in Glasgow from influenza for 1896 was recorded as six; for 1897, twelve; for 1898, fifteen; 1899, twenty-two and for 1900, twenty-seven.

The disease was present in Lima, Peru in March, 1900, and at Malta in the same month. In Prague it was stated that ten per cent. of the population had been attacked in the winter of 1901. In Sivas, Turkey, fifty per cent. of a population of 50,000 were estimated to have been taken ill within the winter months. It was reported from Valencia, Spain, that there had been four or five visitations of influenza since the preceding pandemic, each recurring invasion presenting a milder and less expansive form than its predecessor. Very few deaths had been recorded as directly due to influenza, but an increased mortality followed the epidemics. In normal times the average mortality was ninety deaths per week. After a visitation of influenza the number

had increased to as much as 160 per week. The population numbered 204,000.

Period from 1901 *to* 1915.—Between 1900, with its wide distribution of a very mild influenza, and 1915, there is very little mention of epidemic prevalence of the disease. References which appeared in the Public Health Reports during the interval are characterized chiefly by their brevity, and by the absence of descriptive detail. They should nevertheless be included.

In October of 1901 there was some increase of the disease in the Hawaiian Islands, 110 cases being reported on the island of Kauai.

At the same time, C. Williams Bailey reported a mild form of influenza existing in Georgetown, S. C., which was first considered to be hay fever in consideration of the presence of the rice harvest season, but which was finally decided, after careful investigation, to be true influenza.

On July 21, 1902, the U. S. Consul at Canton, China, telegraphed that influenza "was almost epidemic, plague sporadic in Canton."

In 1903 the disease was reported as apparently prevalent at New Laredo, Texas.

Surgeon Gassaway, of the Marine Hospital Service, reported from Missouri, December 14, 1903, as follows: "There is a very decided increase in the number of cases of influenza in this vicinity. Two have been admitted within the last few days to this hospital, and several cases have appeared among the patients under treatment. In these cases the onset is sudden and the disease appears principally, at least at first, to be confined to the nose and throat."

Measles and influenza were reported prevalent in Barbados, West Indies, during the month of December, 1904.

Sturrock describes a quite typical local epidemic in a British institution in 1905.

Influenza was epidemic in Guayaquil and various other places in Ecuador during the months of June and July, 1906.

Selter speaks of a true local epidemic of a disease clinically resembling influenza which occurred in 1908 and extended over the territory from France to the Rhine.

Hudeshagen mentions having examined bacteriologically cases of influenza in the year 1914.

Ustvedt relates his experience at the Ullevaal Hospital up to September, 1918. Since 1890 there had been cases reported every year from the high marks of 10,461 cases in Christiania in 1890 and 5,728 in 1901 to the lowest figure, 138 in 1906. "The cases listed as influenza in the last few years may have been merely a catarrhal fever.

This is the more probable as the cases were restricted to the winter months, while influenza usually occurs at other seasons."

Jundell believes that influenza is endemic at Stockholm, Sweden, hundreds of cases being reported there each year. During the years 1912–1919 Pfeiffer's bacillus has been found in ten per cent. of those cases in which the diagnosis seemed certain.

A current comment in the Journal of the American Medical Association in 1912 remarks that epidemics of coryza, sore throat, and bronchitis usually have been called influenza or grip because of the characteristic contagiousness and the infectivity, the persistence of the symptoms, and the tendency to prostration and mental depression. But this diagnosis has not been satisfactorily confirmed by bacteriologists. An epidemic according to the Journal, which occurred in Boston and which was called sore throat, was studied by Richardson and others. They traced the contagion to a streptococcus which apparently was spread by means of milk. Müller and Seligman had recently carried out a study of an influenza epidemic among children in Berlin and concluded that the causative organism was a streptococcus, differing so much from the ordinary germ that they used the term "grip streptococcus." Davis and Rosenau, according to the comment, had made a bacteriologic study of a recent epidemic of sore throat in Chicago, and had demonstrated as the exciting agent a streptococcus of peculiar characteristics, which in many respects resembled the organism described by Müller and Seligman. The Journal noted that these three epidemics occurring during the years 1911 and 1912 in widely separated communities were all caused by the streptococcus, and cautioned against the proneness to call all such epidemics grip. Today the predominance of the streptococcus would not necessarily rule out influenza in our minds.

In the winter of 1913, C. L. Sherman had occasion to study carefully fourteen cases of so-called influenza in the vicinity of Luverne, Minnesota. Bacteriologic smears and cultures were made from the throat and sputum in all cases. Bacillus influenzae was found in two of the fourteen; pneumococcus in four and streptococcus in all. Tubercle bacilli were found in one case. The onset of the disease was invariably abrupt. The fever in all cases ranged between 101° and 104°; symptoms indicative of infection of the upper respiratory tract were always present. There was more or less sore throat in all. There was either cough at the onset or else it appeared within 48 hours. Headache was complained of by twelve of the fourteen; pains in the back and in the limbs by thirteen, and nervous symptoms by

six. Prostration out of all proportion to the fever and other symptoms prevailed. Two developed an otitis media and the streptococcus was isolated from the purulent discharge in both cases. One patient had a complicating empyema, and one an acute arthritis. Sherman also concluded that we are prone to call too diverse diseases influenza.

Walb stated in 1913 that at Bonn during the preceding years there had been numbers of cases of a febrile affection which seemed to be typical influenza, but for which the pneumococcus appeared to be responsible. They were never able to isolate the influenza bacillus, and according to their statement the Hygienic Institute at Bonn, as well as that at Berlin, had not "encountered an influenza bacillus within the preceding ten years."

C. T. Mayer described in 1913 a case of influenza in Buenos Ayres which is of particular interest in view of one of the symptoms, cyanosis, which was so prominent a feature in 1918. This appears to have been an isolated case. The diagnosis wavered between miliary tuberculosis and pneumonic plague, because of the high fever and intense cyanosis, with nothing to explain the cyanosis on the part of the heart. There were signs of severe congestion of both lungs, and notable enlargement of the spleen. Bacteriologic examination was negative except for the presence of Bacillus influenzae and Micrococcus catarrhalis. The patient subsequently improved rapidly, and the lungs were entirely normal after thirty days, thus ruling out the other two diseases.

A London letter to the Journal of the American Medical Association dated February 5, 1915, runs as follows:

"Since the outbreak of the war the public health has been remarkably good, but the record is now being threatened in the case of London, at any rate, by an epidemic of influenza.

"The gastric symptoms which distinguished last year's epidemic are absent. The disease is most infectious. Whenever it has seized the individual it has usually run through the entire household.

"Whole offices have succumbed, and as the mildness of the attack lures the sufferer to continue his normal occupation, the disease has a full opportunity of extending. A large number have resulted in pleuro-pneumonia; otherwise the chief symptoms are headache, fever, tonsillitis."

Telling and Hann describe another clinical diagnosis of influenza, the diagnosis being concurred in by Sir James Goodhart and Sir Clifford Allbutt. The onset was absolutely sudden at a supper party on November 10, 1912. The patient had a slight rigor, and was

compelled to go to bed. In the night he had a longer and more severe rigor, with a temperature of 103°. On the following morning he dressed, but another chill sent him back to bed with a temperature still 103°, pulse 110, regular, and remarkably dicrotic. There was no cough and no sore throat. Another chill occurred in the evening. On November 12th the patient had two chills, the temperature remaining steadily at 103° to 104°. The patient complained much of nausea but did not vomit. On November 13th the temperature remained up, there was no chill on this day; the spleen was large and easily felt for the first time. On the 14th note was made that there was no headache. On the 15th, 16th and 17th the temperature began to fluctuate. On the 18th there were two severe rigors, and by the 19th the temperature suddenly fell to normal, with drenching sweat. Throughout there was nothing to suggest pneumonia, and typhoid fever appears to have been successfully ruled out.

An epidemic of influenza which prevailed in the city of Pittsburgh, Pennsylvania, from December to February of 1907 and 1908, has been described by J. A. Lichty. He says that the epidemic was as widespread, though probably not quite as severe, as the pandemic of 1889. Whole families, including servants and all associated with the household, were afflicted in rapid succession. The onset was sudden and severe, the usual symptoms of pain, all over, being most pronounced. The temperature did not go unusually high, nor did it seem to be in accord with the severity of the symptoms when the patient took to his bed. In typical cases the attack lasted from two to three or four days. Peculiar to this epidemic seemed to be the general complaint of sore throat. Upon examination the throat rarely showed any other evidence of an abnormal condition than a rather dark cyanotic blush, which was most intense over the tonsils and faded out over the roof of the mouth. This was rarely associated with any swelling or fever. Sinusitis and otitis media seem to have been the two most frequent complications. The disease appeared to be particularly fatal for chronic invalids. It was highly contagious. Many of those physicians who were frequently exposed to the disease fell victims.

At the same time C. H. Jones described an epidemic of the same disease in Baltimore. The symptoms were described as headache, backache, limbache, with a slight elevation of temperature, seldom more than 102°. Catarrhal symptoms developed secondarily and were not so prominent a feature as in former epidemics. There were some gastric symptoms, usually consisting of vomiting and nausea.

Jones quotes no statistics, but feels sure that the infection was more extensive than at any period since 1895.

Coakley and Dench describe throat and ear complications as they saw them in New York. From this we may assume that the disease was present at the same time in New York City.

The following chart, derived from the U. S. Vital Statistics Report shows the increase in the death rates from influenza in 1900 and 1901; that of 1907 and 1908, and finally an increase to 26.4 per 100,000 in 1916, which reflects the epidemic beginning in the latter part of 1915:

Influenza and Pneumonia Mortality in the United States Registration Area for Each Year Since 1900.

Year	Annual death rates per 100,000.		
	Pneumonia.	Influenza.	Combined diseases.
1900	158.6	22.8	181.4
1901	133.5	32.2	167.7
1902	124.7	10.1	134.8
1903	122.6	18.5	141.1
1904	136.3	20.2	156.5
1905	115.7	18.8	134.5
1906	110.8	10.3	121.1
1907	120.8	23.3	144.1
1908	98.8	21.3	120.1
1909	96.3	13.0	109.3
1910	147.7	14.4	162.1
1911	133.7	15.7	149.4
1912	132.3	10.3	142.6
1913	132.4	12.2	144.6
1914	127.0	9.1	136.1
1915	132.7	16.0	148.7
1916	137.3	26.4	163.7

At best our information for these years is unsatisfactory. It is greatly to be desired that individuals who have access not only to the current medical literature, but also to the vital statistics and other records for all countries possessing reliable records, and who are versed in the newer mathematical methods of demography, establish definitely the influenza prevalence and distribution during these inter-pandemic years. The difficulty in this work is that mortality statistics are unreliable and morbidity statistics are lacking.

Influenza in 1915–1916.—Until the end of 1915 there was no widespread distribution in the United States similar to that of 1900 and 1901, but at that time there developed a widespread epidemic in this

country of similar or possibly slightly greater severity than that of fifteen years previously. Reference to the last table will show that during 1916 the annual death rate from influenza as reported in the United States Vital Statistics reached the rate of 26.4 per 100,000. According to V. C. Vaughan the literature of that time shows that this epidemic originated in the West, first attracting attention at Denver, and gradually spread over the country.

Dr. Dublin of the Metropolitan Life Insurance Company gives the following table in which the deaths from influenza and pneumonia during the months of December, 1914, and January, 1915, are compared with deaths from the same cause during the months of December, 1915, and January, 1916:

Name of city	Deaths reported as due to influenza.		Deaths reported as due to pneumonia.	
	In 1915–16.	In 1914–15.	In 1915–16.	In 1914–15.
Baltimore	57	12	219	101
Cincinnati	81	2	105	84
New Orleans	97	44	35	29
New York	494	62	2,067	1,207
Philadelphia	324	62	564	272
Providence	38	3	31	31
Total	1,091	185	3,021	1,724

Dublin states that the Industrial Department of the Metropolitan Life Insurance Company, covering the entire country and embracing ten millions of people, had deaths in the periods above mentioned, as follows:

In December, 1914, and January, 1915, the number of deaths attributed to influenza was 165
While in the corresponding months of 1915–1916 the deaths attributed to influenza were 957
The deaths attributed to pneumonia in December, 1914, and January, 1915, were 1,468
While the number of deaths attributed to the same cause in December, 1915, and January, 1916, were 2,563

Coffey and others have reported an epidemic of influenza at Worcester, Mass. during the first three weeks of January, 1916. During the first three weeks of January, 1915, there were reported in that city twenty-two deaths from respiratory diseases, making a total of 14.9 per cent. of the total deaths. In the same period of 1916 there were reported ninety-three deaths from acute respiratory diseases in the same population.

Two of the more complete descriptions of the epidemic of the year 1915–16 are those by Mathers, and by Capps and Moody. Mathers reports that: "During the winter of 1915–1916 the United States was visited by a severe epidemic of acute respiratory infections which resembled in every detail the great epidemic of 1890. This outbreak was apparently first noticed in the Middle Western States, and it spread rapidly over the entire country, taking a heavy toll of human life. December and January were the months in which these infections were most prevalent, and the epidemic had almost completely lost its impetus by March, 1916. During the height of this epidemic in Chicago, sixty-one cases of the disease were studied bacteriologically, and the results form the basis of this paper."

Mathers found hemolytic streptococci in forty-six instances, in all of which they predominated. Green producing streptococci were found thirty times, with one pure culture, and pneumococci thirty times with four pure cultures. Staphylococci were isolated in fifty cases; Micrococcus catarrhalis in six, and Friedländer's bacillus in one case. The influenza bacillus was found in only one instance, and then in small numbers. The majority of the patients were studied early in the course of the disease, and in the earliest, hemolytic streptococci were almost constantly found, especially in the throat. In the atypical pneumonia which followed many of the attacks of grip, hemolytic streptococci predominated. In none of these was the Bacillus influenza found.

Mathers reported that coincident with the epidemic among humans there was an epizootic of so-called influenza among horses. The symptoms are very similar to that of the disease among humans. He isolated a streptococcus as the predominating organism in the horses. The streptococci from human and equine sources, although similar in many characteristics, differed widely in pathogenicity, and seemed to be highly parasitic for the specific hosts.

Capps and Moody found that in man most cases began rather abruptly, with coryza, pharyngitis, laryngitis, or bronchitis.

"The chief complications were inflammation of the accessory sinuses of the head, and bronchopneumonia, the latter being responsible for most of the fatalities. None of these symptoms taken alone would justify the distinctive name of grip. But the widespread and almost simultaneous onset of this fairly uniform symptom group and the rapid cessation of the epidemic after a few weeks reminded physicians generally of the great grip pandemic of 1889–1890. This resemblance was further strengthened by the unusual prostration lasting days or

weeks after even mild attacks. The older practitioners can recall no similar epidemic during the twenty-five years intervening between 1890 and this year. The numerous epidemics of septic sore throat have all been entirely different in their symptomatology, and all were restricted to certain localities. The term "grip," therefore, seems justified from a clinical standpoint.

"The public health reports offer evidence of an unusual prevalence of pneumonia in the larger cities. Nicolas calls attention to the fact that the incidence of grip was greatest in those cities in which the mortality from pneumonia was most strikingly increased."

Capps and Moody found that as a rule the white blood counts in the individuals sick with influenza were 10,000 or less. A number showed true leucopenia. Less frequently there was a leucocytosis up to 15,000 or higher.

Influenza between 1916 *and* 1918.—Zinsser cites Dr. George Draper, who believes that he observed at Fort Riley in the winter of 1917 epidemic cases of influenza. He believes that for Europe too there is evidence that influenza was endemic during the years preceding the great outbreak, and that a number of minor epidemic explosions had occurred in the years just preceding 1918:

"MacNeal who has investigated military reports particularly, states that small epidemics occurred in the British Army in 1916 and 1917. A chart constructed by him from the American Expeditionary Force reports shows that a considerable rise in reported influenza cases took place in November and December, 1917, and in January, 1918, gradually declining toward spring. MacNeal, compiling the data available in the office of the Chief Surgeon. A. E. F., states that the influenza morbidity reported per 100,000 for succeeding months in 1917, were as follows:

July	321
August	438
September	404
October	1,050
November	1,980
December	2,480

"Robertson, who studied many of the secondary pneumonias which came to autopsy at this time found an unusual type of lobular pneumonia in which Pfeiffer bacilli were frequently found. In many of these cases the organisms could be obtained from the nasal sinuses and antra. Similar findings were reported by British bacteriologists (Hammond, Rolland and Shore, and Abrahams, Hallows, Eyre and

French), who studied the cases that occurred in the reports by Austrian physicians in reference to outbreaks of typical influenza on the Austro-Russian front early in 1917.

"There seems little doubt, therefore, that for some years before the pandemic of 1918 influenza was endemic in many parts both of Europe and of America. As early as 1915–1916 Frost finds evidences of limited epidemic outbreaks in the United States. During the winter immediately preceding the true beginning of the pandemic small outbreaks occurred among the allied troops in France, the British troops in England and probably among American troops gathered in home concentration camps as well. MacNeal in a summary of the conditions prevailing among American troops in France concludes that epidemic influenza in that country originated from the endemic foci there existing, and that the disease was probably carried from Europe to the United States by shipping. The former assumption; namely, that the epidemic occurrence of the disease may have been due to the fact that an enormous and concentrated newly introduced material of susceptibles may have been lighted into flame at the numerous endemic smoulders, may well be correct. The latter, however, concerning the transportation of the disease from Europe to America may justly be questioned. For, in the first place, Frost's studies have shown that prepandemic outbreaks were quite as frequent in the United States as in Europe during 1915 and 1916, and, though we have no proof of this, there is reason to believe that influenza was prevalent in concentration camps during 1917."

Carnwath, after remarking that the epidemic began in the British Army in France in April, 1918, says that according to the reports of the Influenza Committee of the Advisory Board this was not the first time that Pfeiffer's bacillus had appeared in the armies. On the contrary, it had frequently been found in cases of bronchopneumonia, especially during the winter of 1916–1917. It is doubtful, however, whether much importance, from the epidemiologic point of view, attaches to these sporadic findings of the Pfeiffer bacillus.

Influenza was reported in the year 1917, but this year, as well as the epidemic of 1916, becomes involved in a determination of the date of onset of the great pandemic of 1918.

The Pandemic of 1918.

The date and site of onset of the great pandemic are subjects concerning which there is no conclusive information. There have been small outbreaks of clinical influenza with epidemic tendencies at one

place or another during nearly all of the intervening years since 1889. In all of them the question is open as to whether they were true influenza, and also assuming that some were true influenza, how many of them should be so included. There are some who believe that the increase of morbidity following the measles epidemic in the United States Army camps in the winter of 1917–18 is genetically associated with the great pandemic. In short, there is no one point in the last few years at which we may say that influenza which had previously been non-existent started at a focus and spread throughout the world.

It follows from the experience of 1889 that we should at least attempt to find an endemic focus and to follow the progression of the disease. It is safe to say that once having become pandemic the disease spread as it did thirty years previously. Experience in this country, where the autumn spread began in the New England States and continued West and South; knowledge of the late spread to remote localities; the fact that the disease first appeared in England, etc. in sea coast towns; the introduction of the influenza into new countries at seaport towns, after the arrival of infected ships, all coincide well with the past history.

But which of the several local epidemics of the preceding years was the direct progenitor of the great pandemic? In order to follow more clearly the development of the facts we will record here the various hypotheses that will come up for consideration as to the site of origin of the disease.

1. Influenza is endemic in some one locality, such as Turkestan in Asia, from which place the disease spreads throughout the earth at intervals, after having acquired in some way greatly increased virulence. The local outbreaks of interepidemic times are not due to the virus which causes the great pandemics and should be called pseudo-influenza in contrast to influenza vera. Following the pandemic it is true, however, that for a succession of years local outbreaks occur, due to the pandemic virus which has been left deposited in small endemic foci. These disappear in the course of a few years.

2. The second hypothesis is similar to the first, except that in it is considered the possibility of there being more than one endemic focus, at least two, one in the old world and one in the new. Although Leichtenstern believed in the first hypothesis he did not deny the possibility of the second.

"There have been in the past several well described influenza epidemics limited to North America. Furthermore true pandemics have occurred at the same time in North America and in Europe. We

can suggest the hypothesis that there is a permanent endemic focus, just as in central Asia and Russia, existing in the southern part of North America. The following facts concerning the last pandemic period favor this idea.

"As early as May, 1889, influenza began in Athabasca (British North America) and in the summer of 1889, in Greenland. It is especially interesting to hear of an extensive influenza epidemic which in the middle or toward the end of December, 1889, broke out in the Northwest Territory of British North America, in Manitoba, in the Island of Vancouver, similar to that in the east of Canada and Quebec. A spread of the epidemic, which attacked Boston and New York on December 17th, to the above territories, far away and connected by very poor transportation facilities, is certainly improbable, especially in consideration of the time at which the two epidemics occurred.

"We are told that the invasion and the outbreak of influenza in these vast territories occurred at practically the same time at such widely separated places as Fort MacLeod, Saskatchewan, Prince Albert and other military posts, and furthermore in isolated Indian camps and tribes between which there was little or no communication.

"These facts also indicate that we are considering primary endemic pandemics analagous to the one which broke out in July, 1889, in Central Asia."

3. The virus of influenza is more or less uniformly distributed throughout the world. We may say that it is endemic in many localities, as is the case with the meningococcus. Quite frequently in one locality or another the virus acquires increased virulence and causes a small local epidemic which may even spread to adjoining territories. It is possible that the virus in two or more separated localities may become more invasive simultaneously, thus causing widely separated and unrelated outbreaks. As a rule the virulence does not become so great as to cause a true pandemic, but at rare intervals, usually of decades, or thereabouts, the epidemic virus becomes so greatly enhanced, perhaps from passage to new territory and through non-immune individuals, that it eventually commences on its wild career around the earth. Perhaps the *pandemic* variety usually comes from one particular locality among the many endemic spots. Perhaps always from the same locality or perhaps at times even simultaneously from many different ones. It is possible even that an increased virulence develops simultaneously in all localities. This third hypothesis develops into a discussion as to whether the small interpandemic epidemics are true influenza or some other disease.

Again, Leichtenstern, although he does not favor it, recognizes the possibility of this theory:

"Whether the small local epidemics reported by Kormann in Coburg in 1878 and by O. Seifert in Würzburg in 1883 are the same as the true epidemic influenza is at present uncertain. Some of the complications, such as swelling of the neck glands, and especially frequently parotitis, purpura, scurvy, indicate that the epidemic in Russia, in 1856–1858, reported by Kasin, was not the true influenza.

"When W. Zülzer writes in 1886 of an epidemic in Berlin in which many thousands of individuals were attacked, the question might arise, is this the same influenza which three years later passed through the entire world and which in Berlin was believed by the same physicians to be a new disease?

"The evidence is better in the case of the epidemic reported by von den Velden in 1874–75. First, because of the complication with pneumonia and especially because at the same time the disease sprang up in several places in France, South Germany and the Rhine Provinces. It is very doubtful whether epidemics described in 1855 and 1862 in Iceland, in 1870 in Philadelphia, in 1875 in Scotland, in 1876 in the Fiji Islands, in 1887 in several places of England, in October, 1889 in Natal, in November, 1889 in Jamaica and Prince Edward Island, was the true influenza, even though the complications of pneumonia in the last named epidemics favor this assumption. As regards the influenza epidemic which attacked specially the school children of Pleshey and Great-Waltham and from which fifty per cent. became ill in November and December, 1889, whereas the pandemic was known to have begun there in January, 1890—the high percentage of school children that were attacked renders the conclusion that this was influenza very doubtful.

"It is an entirely different matter concerning the last epidemic in which the epidemiologic compilations, based on retrospective diagnoses suggest that in many places of Germany the 'first case' of even small epidemic outbreaks was observed as early as the summer and autumn of 1889; in other words, several months before the outbreak of the true pandemic in December."

Leichtenstern believed that the so-called catarrhal fever and epidemics of "cold" which some have been accustomed to call grip or influenza are not the true disease, although he admits that there is no pathognomonic sign by which the diseases may be differentiated. He expected that search for the influenza bacillus which had recently been discovered would enable investigators to determine by its

presence or absence whether or not these local epidemics are true influenza.

This, of course, would depend on the proof that the influenza bacillus is the cause of the disease. If the many local influenza outbreaks which Hirsch has collected in his exhaustive historical tables are the same disease as true influenza, then the picture of influenza must be considered as rather protean. Leichtenstern adds that this is a possibility which from present information we cannot deny. He writes: "If such is the case we must give the following epidemiological definition of influenza: Influenza is a specific, infectious disease usually occurring epidemically which, however, is endemic over the entire earth, as indicated by outbreaks of cases, and which, after years and decades have passed, breaks out in epidemic proportions. It is recognized nearly every year in one or another place on the earth where it becomes epidemic. From time to time from some point or center, or from several points, as for instance simultaneously in the old and new world, and for reasons unknown to us, an enormous increase in virulence of the specific virus occurs and with it a great increase in the contagiousness of the disease. Those are the times when influenza spreads in mighty epidemics over wide stretches of land and portions of the earth, or over the whole earth. Our common epidemic influenza or grip, occurring practically isolated or in very small outbreaks, belongs to the same type of disease as the pandemic variety, but is due to a mitigated form of the causative organism, one of decreased virulence and of shorter viability.

"*Provisionally, however, we will hold* until the proof has been obtained by bacteriological methods that influenza nostras and influenza pandemica are two entirely different diseases, just as are cholera nostras and asiatica. Accordingly, we will divide the diseases designated as influenza in the following way:

"1. Influenza vera, caused by the Pfeiffer bacillus.

"2. The endemic-epidemic influenza vera which arises from the germ remaining after the spread of the influenza pandemic and which is caused by the same germ, the bacillus of Pfeiffer. The duration of this endemic state of influenza vera may last years in single localities.

"3. The endemic influenza nostras, or pseudo-influenza or catarrhal fever, commonly called grip, a disease sui generis. The germs causing this disease are at present as little known as are those of cholera nostras."

Parkes, in 1876, recognized these possibilities: "The exact spot has not been made out. Two opinions prevail. First, one focus;

second, many foci. Each nation, in turn, attributes the disease to its neighbor and from the names so given one can follow the direction of the epidemic." Noah Webster believed that in 1698, 1757, 1761 and 1781 it originated first in America. Hirsch believed that some of the epidemics had probably originated in North America.

We find then that after the pandemic of the last century the same epidemiologic questions had arisen that have come into such prominence during the present period. As a rule those who have quoted the epidemiologists of 1890 to 1900 have mentioned the first hypothesis and have failed to allude to the fact that the other two were considered. So we see that the subject was by no means settled even at that time, and that if we should discover that the 1918 pandemic cannot be traced to a single endemic focus our results will not be absolutely contradictory to those of the last century.

Returning to a consideration of the period 1916–1918, we observe from reference to Frost's diagram that in the spring of 1918 there was a sharp and general rise in mortality from influenza and pneumonia. Frost reports that in the larger cities on the Atlantic seaboard this increase occurred generally during January, February and March, when pneumonia mortality normally reaches its maximum. The increase was not so evident in all these cities as it was in New York City. In the rest of the country, especially in the Central and Western States, the increase occurred in April, a month during which pneumonia mortality is generally on the decline, and was sufficient to constitute an unmistakable departure from the normal. The increased mortality rate extended quite generally into May and in some areas still longer. This is the first increase after 1916 that is pictured in the mortality statistics for the country at large.

There are some who believe that they saw influenza in mild form in the United States army in the year 1917. V. C. Vaughan has investigated this possibility and from a study of the sick and wounded charts decided that there was no relation between influenza and the pneumonia which was prevalent in 1917, and which usually was secondary to measles, being caused by the streptococcus in the majority of localities. The lack of association between influenza and pneumonia in 1917 and the direct association in 1918 is well brought out by a comparison of the figures in the two following charts, prepared by V. C. Vaughan:

Pneumonia as a Sequel to Respiratory Diseases.
(All troops in United States in 1917.)

Primary diseases.	No. of cases.	No. of cases followed by pneumonia.	Per cent. of cases followed by pneumonia.
Measles	47,573	2,075	4.37
Scarlet Fever	1,966	54	2.75
German Measles	8,982	39	0.43
Bronchitis	41,233	20	0.049
Influenza	32,248	19	0.059
Meningitis	1,027	13	1.27
Tonsillitis	43,021	7	0.016
Pulmonary tuberculosis	6,799	6	0.088
Laryngitis	4,633	2	0.043
Diphtheria	1,163	1	0.086
Mumps	21,725	0	0.000
Pharyngitis	8,096	0	0.000

Influenza and Pneumonia in Last Four Months of 1918.

Number of cases of influenza	338,343
Number of cases of influenza followed by pneumonia	50,700
Number of deaths from influenza pneumonia	17,700

Stallybrass, who has studied the influenza and pneumonia deaths in Liverpool, England, since the 1889 pandemic, states that in every year there had been reflected in the curves evidence of periodic increase in deaths from influenza and pneumonia, and he states that from 1914 onward there has been a progressive increase in the annual number of influenzal deaths with the single exception of 1917.

It becomes evident that we cannot with the information at hand find any one locality in which the disease was prevalent sufficiently ahead of the pandemic and to the exclusion of other localities, so that we might determine accurately the site of origin. The next step will be, then, to discover as accurately as possible the date at which various communities were first definitely attacked by the great pandemic, and to search out the locality first affected.

Date of First Increased Prevalence in Various Localities.

From table II which gives the earliest recorded dates of increased prevalence in different localities, we can gain a fairly accurate idea as to the direction and manner of spread of the disease during the pandemic. Influenza was first noticed in the United States early in March, 1918. By the end of the month it had become more disseminated in very mild form over many of the States east of the

TABLE II.

The spread of influenza in 1918.

Month.	Date.	Country.	City.	Authority quoted.
March		*China*		McNalty, Carnwath.
		Japanese Navy		McNalty, Carnwath.
		Japan		Jour. Am. Med. Assn.
		France	Civilian Population at Chaumont	MacNeal.
	5	*United States*		
		Kansas	Camp Funston	Opie.
		Missouri	Kansas City	V. C. Vaughan.
		Illinois	Chicago	Frost.
		Ohio	Columbus	V. C. Vaughan.
		Michigan	Detroit	V. C. Vaughan.
	18	Georgia	Camp Greenleaf	V. C. Vaughan.
			Atlanta	V. C. Vaughan.
	28	S. Carolina	Camp Sevier	W. T. Vaughan.
	30	Kansas	Haskell	Public Health Reports.
April		*United States*	Various points from Norfolk to Louisiana	Public Health Reports.
		Mississippi	Camp Shelby	V. C. Vaughan.
		Georgia	Camp Hancock	Forbes and Snyder.
	30	California	San Quentin Prison	Stanley.
		France		Netter.
				Chauffard.
				Messary.
				Longcope.
	1		Brest (American Expeditionary Forces)	V. C. Vaughan.
			British Expeditionary Forces	Carnwath.
			Allied Western Front	Public Health Reports.
	1		German Western Front	Gins.
May		*France*	Chaumont	Zinsser.
		Scotland	Glasgow	Dunlop, Carnwath.
		Spain	Madrid	Office International d'Hygiène Publique.
		Greece	Athens	Filtzos.
		Macedonia	French Army	Teissoniere, Beguet and Jolly.
		Egypt	Egyptian Expeditionary Forces	Benjafield.
		Italian Navy		MacNeal.
June		*England*	Portsmouth	Carnwath.
	15		Birmingham	Public Health Reports.
	1	*Switzerland*	Zürich	Office International d'Hygiène Publique.
	1	*Germany*	Frankfurt, A. M.	Deutsche. med. Wchnschr.
	3		Strasbourg (Alsace)	Rose.
	25		Bonn	Koepchen.
	At the end of the month		Berlin North & South Germany	Deutsche. med. Wchnschr.
	Late	*Austria*	Vienna	Bohm.
	15	*Norway*	Christiania	Public Health Reports.
	15	*China*(?)	Chefoo	Public Health Reports.
	16	*Brazil*	Santos	Public Health Reports.
	22	*India*	Bombay	Public Health Reports.
		Porto Rico		Atiles.
		Philippine Islands		Hernando

TABLE II (*Continued*).
The spread of influenza in 1918.

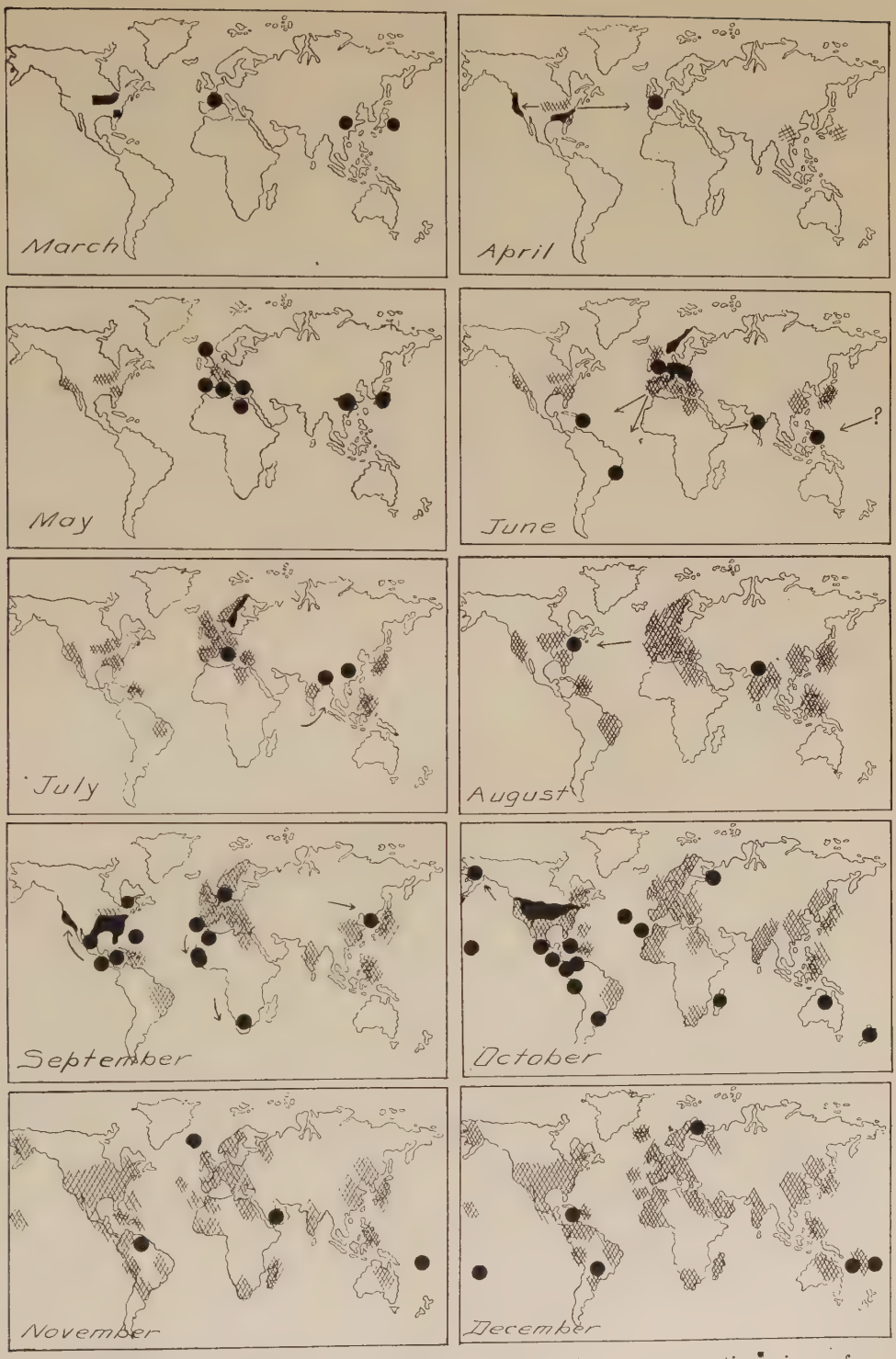
Month.	Date.	Country.	City.	Authority quoted.
July	1	*Germany*	Dresden	Schmorl.
		Italy		Office International d'Hygiène Publique.
	13	*Sweden*	Malmo	
			Gothenburg	Frost and Sydenstricker.
	Late	*Netherlands*	Flushing	Public Health Reports.
	27	*China*	Chungking	Public Health Reports.
		India	Calcutta	Malone.
August		*India*	Punjab	Jour. Am. Med. Assn.
	3	*West Indies*	Guadeloupe	Public Health Reports.
		United States	Boston	Second Spread.
September		*Denmark*		Frost and Sydenstricker.
	11	*Republic of Salvador*		Public Health Reports.
	16	*Honduras*		Frost and Sydenstricker
	25	*Bermuda*		Frost and Sydenstricker.
	30	*Jamaica*		Frost and Sydenstricker.
		Mexico	Santa Cruz	Frost and Sydenstricker.
	21	*Canada*	Victoriaville	Frost and Sydenstricker.
			Quebec	
			Hamilton	
	30	*Portugal*	Lisbon	Public Health Reports.
	28	*Morocco*	Tangier	Frost and Sydenstricker.
	14	*South Africa Union*		Frost and Sydenstricker.
	16	*Senegal*	Dakar	Public Health Reports.
	16	*Sierra Leone*	Freetown	Public Health Reports.
		Korea		Schofield.
		United States	West and South from Boston	
October	Early	*Alaska*		Governor's Annual Report.
	1	*Russia*	Archangel	Frost and Sydenstricker.
		Peru	Lima	Soldan.
		Uruguay	Montevideo	Frost and Sydenstricker.
	25	*Venezuela*		Frost and Sydenstricker.
	11	*Guatemala*		Frost and Sydenstricker.
	12	*Costa Rica*	Limon	Frost and Sydenstricker.
	26	*Colombia*	Begota, Barranguilla.	Frost and Sydenstricker.
			Cartagena, Peru.	Frost and Sydenstricker.
	9	*Cuba*	Camagney, Nuevitas	Frost and Sydenstricker.
	22	*Azores*		Public Health Reports.
	18	*Canary Islands*		
	19	*Madagascar*		Frost and Sydenstricker.
	17	*Australia*		Frost and Sydenstricker.
	19	*New Zealand*		Frost and Sydenstricker.
		Hawaii	Honolulu	Frost and Sydenstricker.
November		*British Guiana*		Rose.
		Dutch Guiana	Paramaribo	Frost and Sydenstricker.
	22	*Samoa*	Apia	Frost and Sydenstricker.
		Arabia	Aden	Frost and Sydenstricker.
		Iceland		Erlendsson.
December		*Paraguay*	Paraguay, Asuncion	Frost and Sydenstricker.
	19	*Dominican Republic*	La Plata, Puerto Plata, Santo Domingo	Frost and Sydenstricker.
		Lapland		Macklin.
	8	*Society Islands*		Frost and Sydenstricker.
	3	*Tonga Islands*		Frost and Sydenstricker.
		Fiji Islands		Frost and Sydenstricker.

Mississippi and a few West of that line. The following month the disease appeared in France. In the American Expeditionary Forces in France it first appeared at the base ports which were receiving troops from the United States. During this month the disease had reached the allied Western front, the German front had become infected and probably the disease had started on its travel inward into enemy country. In May the disease was reported present in Scotland, Spain, Greece and Egypt. In June England became infected, as also Switzerland, Germany, Austria and Norway. In this month the disease had reached as far as South America and India. In China, on the 15th of June, there was reported an epidemic of a disease resembling dengue which affected fifty per cent. of the population in Chefoo and Shanghai. This disease may well have been influenza. During July the disease had spread through Germany, appearing according to German reports in the cities toward the West earlier than in Berlin and other more Eastern cities, including Vienna. In July the disease was present in other countries of Europe and was again reported in China and India.

During its course through Europe influenza had developed a greatly heightened virulence and toward the end of August it again appeared in the United States apparently traveling in a reverse direction from that of its first spread and, entering the country at Boston, it spread to the West and South until the entire country was covered. The West Indies were invaded early in August and in the same month the disease had spread through India as far as the Punjab. In September the epidemic continued through the West Indies attacked Mexico and Canada, and had attained such remote localities as the South Africa Union, Senegal and Korea. In October the spread was particularly distributed through South America, and in this month again remote localities such as Alaska, New Zealand, the Hawaiian Islands, Australia, and Madagascar were reached. Islands, which although not very remote, were isolated except for the arrival of occasional ships, such as Cuba, the Azores and the Canary Islands, were first reported attacked in October. In November the spread continued throughout the world, and among the more remote localities should be mentioned Samoa, Arabia, Iceland. In December, Lapland, the Society Islands and the Fiji Islands were invaded (see Chart XI).

It is particularly of interest to follow the spread of the disease in Europe. Perhaps the chief characteristic is the distribution equally to the north and south of France, a country which appears to have

CHART XI.



Cinematogram showing the spread of influenza in 1918 from a presumptive primary focus in the United States.

been invaded early. In May it spread to Scotland and to Spain, Greece and Egypt. In June the spread was in three directions, to England and Norway on the North, to Switzerland, Germany and Austria on the East, and again into Spain and Italy on the South.

The correctness of the foregoing description of the spread of influenza depends first, upon the accuracy of the authorities quoted, and particularly upon our having discovered the earliest report for each country. The author believes that the information as obtained for the United States represents nearly the true state of affairs, and that the error present is negligible. The information obtained for France is based upon the statements of excellent investigators, Netter, Chauffard and Massary, for the French population, and MacNeal, Zinsser and Longcope, for the American Expeditionary Forces. Here the statements agree both for the military and for the civil population that there was no widespread influenza in France much before April 1st. Also, the author feels that the information for England and Scotland is authoritative and will not later be changed. It is based particularly upon the excellent reports by Carnwath, who has investigated the subject in great detail. The excerpts from the German literature, although not abundant, are practically unanimous in agreeing as to the date of invasion in Germany. The reports from the remaining countries of Europe have been less abundant, and frequently the author has been forced to rely upon a report by only one individual; but while the date may be in error, yet the month of occurrence is probably correct.

For other continents, Asia, Africa and South America, the reports as far as they go appear reliable, but it is impossible to prove that at an earlier date there was not a very mild epidemic in some one of these localities, similar to the earlier epidemic in the United States, which escaped detection. It is particularly important, in view of the 1889 experience, that we obtain if possible fuller information on the earliest time of the appearance of the disease in China and other parts of Asia, and that we determine whether there was a spread from that continent to America previous to March, 1918.

Several factors have added considerably to the difficulty in tracing the site of origin of the 1918 epidemic and its direction of spread. The principal of these have been the speed of modern travel, the character of modern commerce, and the existence of a state of war. The channels of the commerce of today radiate nearly from all points to all other points of the civilized world. No longer are there a few pre-eminent lanes of travel, such as there were in 1580 when the epidemic

spread clearly from Constantinople to Venice and on to Hungary and Germany, finally finding its way to Norway, Sweden, Denmark and Russia. The war has made it difficult to know accurately the date and direction of spread in enemy countries. We have practically no information, except that in the public press, from Russia and the Balkan States. By October of 1918 the severe form of the disease had become prevalent in every continent, and by December it had reached the farthest islands of the Southern Pacific ocean.

The apparent difference in the direction of spread between 1889 and 1918 makes comparison of rapidity difficult. But if we take as our starting point the time at which each epidemic became prevalent in commercial centers of Europe and the time at which it finally reached localities well off the usual paths of commerce we will see that there is some difference, the disease spreading more rapidly in the recent epidemic, but that the difference is no greater than could be accounted for by the more modern means of communication. From April, 1918, when the disease appeared in France, to October, when it was reported in Madagascar, is six months. From October, 1889, with the disease prevailing in Petrograd, to July, 1890, when it appeared in Madagascar, is nine months. It required seven months after the disease became epidemic in France this time for it to appear in Iceland, and nine months in 1889–90.

The earliest recorded epidemic of influenza in the United States in the spring of 1918 (but which was not recognized to be such until later) appears to have been that at Camp Funsten, described by Opie and his associates as having appeared in that Camp March 5th. The epidemic swept quickly throughout the Camp and spent itself as rapidly. A second wave appeared in April and in May a third, both of which were almost entirely limited to newly drafted men brought into camp subsequent to the preceding outbreaks. Correlated with each of these three outbreaks was a period of increased incidence of pneumonia and bronchitis, frequently occurring in influenza cases. These complicating diseases were prevalent in the organizations attacked by the influenza and maintained the same relation to the length of service of the men affected.

The next report of influenza in the United States was from the Oglethorpe camps, beginning about March, 18, 1918. Within two weeks every organization in Camp Forrest and the Reserve Officers Training Camp was affected. After about three weeks the epidemic subsided rapidly. Fourteen hundred and sixty-eight cases were sent to the hospital out of a total strength of 28,586. It is estimated that

2,900 cases had occurred. The clinical symptomatology and the epidemic characteristics were described in detail.

On March 28th the author had occasion to observe a similar epidemic at Camp Sevier, South Carolina, which appears to have attacked a smaller proportion of the troops in camp, but which showed the same epidemiologic picture. A note in the Public Health Reports states that on March 30, 1918, the occurrence of eighteen cases of influenza, of severe type, from which three deaths resulted, was reported at Haskell, Kansas. This is the earliest report we have been able to find concerning the disease in civil communities. That for Chicago was practically contemporary. The Commissioner of Health of Chicago states in his special report on the autumn epidemic, that in March, 1918, distinct epidemics resembling influenza were observed in certain portions of that city.

According to Public Health Reports, fevers of an undetermined nature were reported during April and May at various points from Norfolk to Louisiana. "An examination of the records and reports of the physicians who had treated these cases leads to the belief that these fevers were mainly influenza of mild type." It is possible, however, that all cases reported were not of the same disease, and in one locality in Louisiana dengue may have occurred.

Fleisher states that during the latter part of March and early part of April, 1918, there occurred at Camp Wadsworth an epidemic of measles and practically concomitant with it an epidemic form of bronchopneumonia associated with empyema. During this time there were some 200 cases of measles and twenty-one cases of bronchopneumonia or empyema in which a hemolytic streptococcus was the causative agent. He makes no mention of any epidemic of influenza either in mild or severe form, occurring at this period.

Forbes and Snyder reported that during the month of April, 1918, a highly contagious, but comparatively mild infection of the respiratory tract was epidemic in Camp Hancock. Several thousand men in the command were infected, but relatively few were ill enough to be sent to the hospital. The only fatal case occurred early in the epidemic, and it was the observations made in this case which prompted the study made by Forbes and Snyder.

The fatal case had the subjective symptoms familiar to influenza. The physical findings were similar to those occurring in influenza in the later epidemics. The leucocyte count was 4,300. A blood culture showed in twenty-four hours a heavy growth of small non-motile, gram-negative bacilli which the authors concluded to be Bacillus

influenzae. The leucocyte counts made at five hour intervals on a later date were respectively, 3,400, 2,200 and 2,300. A second blood culture taken on April 10th, a day later, also showed a pure culture of the same organism. The leucocyte count had risen to 5,600. At necropsy a confluent bronchopneumonia was found. There was no pleural effusion and the other viscera showed nothing remarkable. Bacillus influenzae was recovered from cultures taken from the lung and spleen.

Throughout this epidemic the clinical picture of the disease was characteristic. Nearly every patient gave as the initial symptoms backache, headache, slight cough or sore throat. Conjunctivitis and a marked injection of the soft palate were noted in ninety per cent. of the cases. In addition, a slight or moderate general adenopathy was often observed. The face was flushed and in a few cases the skin of the thorax presented a mild erythema. In three cases a provisional diagnosis of scarlet fever was made until the blood count showed a leucopenia. Leucopenia was characteristic of all cases.

During the early April epidemic at this camp, nasopharyngeal cultures showed an organism resembling Bacillus influenzæ in seventeen out of thirty-three cases, but the identity of the organism was not established by subcultures. In ten cases in which sputum examinations were made, Bacillus influenzae was found in only four; streptococci were present in six. Blood cultures on twenty consecutive non-fatal cases, only one of which was complicated by bronchopneumonia, were all negative.

V. C. Vaughan reports that at Camp Shelby, Hattiesburg, Miss., there was in April a division of troops numbering about 26,000. An epidemic of mild influenza struck this camp in April, 1918, and within ten days there were about 2,000 cases. This included not only those who were sent to the hospitals, but also those who were cared for in barracks. This was the only division that remained in this country without change of station from April until the fall of 1918. During the summer this camp received 20,000 recruits. In October, 1918, the virulent form of influenza reached this camp. It confined itself almost exclusively to the recruits of the summer, and scarcely touched the men who had lived through the epidemic of April. Not only the 2,000 who had the disease in April, but the 24,000 who apparently were not affected, escaped the fall epidemic.

Vaughan also remarks that in March and April of 1918 there was an unusually high death rate from pneumonia in Atlanta, Ga., Kansas City, Mo., Detroit, Mich., and Columbus, Ohio, while in the autumn

epidemic these cities suffered rather less than the average. In view of the experience at Camp Shelby he reasons that there was probably mild influenza in these cities in March and April of 1918. It may be stated that in the mortality statistics for 1918, the abnormally high death rates for respiratory diseases during March and April were present throughout the registration area of the United States.

The first reports that we have been able to discover concerning influenza on the Pacific Coast are for the month of April. Stanley reports three successive waves of epidemic influenza at San Quentin Prison, Cal. The first began on April 30, 1918, with the entrance into the institution of a prisoner who was sick on admission.

Following the disease in its possible spread to the next continent we are inclined to conclude that it was carried to France with the great body of men traveling to that country from the United States. MacNeal and Longcope both report that in the first outbreak in the American Expeditionary Forces the earliest recorded epidemic appeared about April 1, 1918, in a rest camp near Bordeaux. It reached its height April 22d and ceased May 5th. According to V. C. Vaughan a mild epidemic of influenza and pneumonia prevailed at Brest and in that vicinity from April 1st to July 31st, 1918. During this time fifty cases of influenza, twenty-six of which developed pneumonia, with two deaths were admitted to the United States Naval Base Hospital at Brest. The disease was prevalent at the same time among the French civil, military and naval groups in the same locality. We see then that in the American Expeditionary Forces at any rate the disease first occurred in two base ports receiving troops from the United States. In May, 1918, a second outbreak was reported from Tours, which lasted from May 1st to May 24th and affected 117 persons. Zinsser reports an epidemic at Chaumont during May and from this time until July more or less extensive epidemics occurred throughout the entire American Expeditionary Forces.

Longcope remarks that the disease was likewise prevalent at this time among the French population and in parts of the British Army. The Influenza Committee of the British Advisory Board determined that in the first British Army the disease became prevalent around May 18th. Carnwath states that in the British Army in France the epidemic began by a few local outbreaks in the first and second Armies in April and May, 1918. Later it spread to the first, third and fourth Armies and affected a very large proportion of the troops.

Small describes two epidemics of influenza in one of the largest General Hospitals of the British Expeditionary Force in France. He says that the first wave began in April, 1918.

The fact that MacNeal, as we have previously recorded, believed that there was influenza in France in 1917, must not be overlooked. Those earlier cases were scattered and did not so far as we know occur in the form of small epidemics. Even if these were true influenza it is reasonable to assume that they were sporadic cases and were not genetically associated with the epidemic spreading from America and daily increasing in virulence, which we are now following. MacNeal concludes that epidemic influenza in France originated from the endemic foci existing there, and that the disease was probably carried from Europe to the United States by shipping. The author's opinion regarding the first direction of spread is that the reverse condition was the actual process. Zinsser likewise holds the latter view.

A most important observation made by MacNeal is that French physicians practicing among the civilian population were perfectly familiar with the disease when it appeared at Chaumont in April, 1918, that they designated it as La Grippe, and stated that it had been extensively prevalent in the civilian population of Chaumont from March 15th to May 15th, 1918. These observations of influenza occurring in France at almost the same date as the first outbreaks in the United States is a matter of great interest. It has also been stated by McNalty and by Carnwath, who quotes Kabeshima and Lee, that the disease was prevalent in epidemic form in China and Japan in March, 1918. We have here three foci from which the disease may have primarily originated. There are two possibilities; first, that it originated in all three foci (and perhaps others), and spread to all parts of the world from each; second, that the virus, distributed throughout the world, acquired high virulence in all three localities, causing small epidemic outbreaks, but that the virus from only one of these places finally became so exalted as to cause the pandemic. Did the *pandemic* disease originate simultaneously in France, in China and in the United States? One fact seems certain, that the influenza which attacked our troops in Europe was influenza imported from the United States. We have seen that it first appeared in the American Expeditionary forces at the base ports. Alberto Lutraria, Health Commissioner of Italy, has reported that the disease was brought to that country from America. A point of significance is the fact that during March and April there was an unusually large troop movement from the United States to the American Expeditionary Forces.

MacNeal says: "The suggestion that the epidemic was introduced from America is supported by the fact that it appeared at a time

when large numbers of Americans were arriving in Europe, which is indeed an outstanding feature correlated in time with the onset of the epidemic."

According to the report of the Influenza Committee, the disease was first seen in epidemic form in April and May in the British Armies in France, but that was not the first time that Pfeiffer's bacillus had appeared within the armies. It had frequently been found in cases of bronchopneumonia, especially during the winter of 1916–17. Carnwath remarks that it is doubtful whether much importance from an epidemiologic point of view attaches to these sporadic findings of the influenza bacillus. In an outbreak of measles and rubella—complicated by purulent bronchitis—which attacked men belonging to the draft of troops from New Zealand between January 1st and March 8th, 1918, the bacillus influenzae was present in twenty-four of the forty sputa examined, and was grown in culture in twenty-one cases. Sellards made somewhat similar observations on measles patients at Camp Devens.

Concerning the French population, Chauffard, Messary and Netter, all remark that the first cases in France developed in April with possibly some cases before that time, and that there were undoubtedly cases in the German Army in April.

We see then that by April the disease has been transferred to France and is prevalent in the various armies. It is natural to assume that the battle front would present no great obstacle to the spread of the disease into the German Army. Gins remarks that the disease was present on the German West front among the troops as early as April, 1918, and that it spread from there more rapidly to the South than to the North.

During the month of May we observe the spread of the disease to Great Britain, where Carnwath, who has made an exhaustive study of the spread in Great Britain, believes that it was imported by the troops from France. Its first recorded appearance in Glasgow was in May. Dunlop, in reporting the successive epidemics in Scotland, observed that in addition to the three well marked epidemics there was a mild one recognizable in Glasgow in May, and that in that city the death rate rose from 14.1 to 20.1, and the weekly number of deaths from pneumonia and bronchitis from 36 to 107.

In England the disease first attracted attention in June, appearing first in the coast towns, chiefly at the beginning among the military and naval forces. The civilian population was severely affected only later. The ports which were earlier attacked were Portsmouth,

Southampton and Liverpool. Inland towns suffered more severely later.

In the same month that the disease broke out in Scotland it appeared in Spain. The Inspector General of Health in that country reported that an epidemic of the disease began at Madrid in the last half of May, 1918, at a period when there was an unusually large gathering of people in the city. Within a short time it had spread rapidly through all the provinces. The increase in death rate became marked on the 27th of May and reached its peak on the 31st, at which time the rate was twice that of the average annual death rate for that period of the year. During the following week there was some oscillation around the peak and then the curve fell away. The epidemic was particularly severe at Madrid, Badajoz, and Seville. It was mild at Barcelona.

MacNeal remarks: "In Spain the disease appeared in epidemic form about the middle of May and this outbreak received great publicity, sufficient to lead to the popular appellation of Spanish influenza. The very rapid and extensive spread of the disease in Spain would indicate that it had been introduced from without rather than transformed from the endemic state in that country. This also appears to accord with the view of those who have studied the epidemic in Spain."

Filtzos reports that influenza first appeared in Greece toward the end of May, 1918. The symptoms were slight and the people who were attacked suffered for three or four days with fever, accompanied by nervous symptoms. It was called at the time "Spanish Fever". Beginning with September the epidemic became worse and caused a considerable rise in mortality. Complications with bronchopneumonia appeared. The decrease in incidence began toward the middle of December, 1918.

According to Benjafield, the pandemic first commenced in the Egyptian Expeditionary Force in May, 1918, but the maximum incidence was not reached until September and October. The cases during the earlier period of the epidemic were on the whole mild in type and of short duration, only a very small proportion being complicated by bronchopneumonia. The epidemic continued from November, through February, 1919, but the number of cases showed a marked decrease during the last two months.

The month of June saw the spread into England which we have already described, and the continuation from the German West front back into the enemy territory.

Rose reports that on the 3d of June, 1918, in Strasbourg the first cases of influenza were reported in his hospital and that by the 15th of the month the disease was practically epidemic. Wachter in reporting cases from Frankfurt a. M. says that the cases of influenza in that city appeared from the beginning of June, 1918. Schmorl remarks that influenza became epidemic in Dresden in the beginning of July, 1918. According to Koepchen, the disease was epidemic in Bonn the 25th of June.

An editorial comment in the Deutsche medizinische Wochenschrift, July 4, 1918, remarks that the influenza pandemic "which probably has spread from Spain in the last few days" has appeared in several places in Germany in the South and the North, and in Berlin. According to the information received up to that time the disease was of short duration and without severe complications. The issue of July 11th reports that the influenza epidemic appears to have already passed its peak in Berlin and that in Süddeutschland the spread of the epidemic has become very wide.

The Office International d'Hygiène Publique records that the pandemic spread throughout Switzerland towards the end of June, 1918, after having invaded a certain number of European states, coming from various army fronts. It was at first of mild severity.

Böhm states that the deaths from pneumonia and influenza in Vienna began to show an increase in the week ending July 30th. In August they returned to the normal rate. The second wave occurred in Vienna in the middle of September.

From the information at our disposal we are unable to determine from what direction the pandemic entered either Switzerland or Austria. The point of entry into Switzerland is of relatively little importance in tracing the spread on the continent of Europe. Presumably it entered from the north or northwest. The disease appeared in Berne in June, reaching its height in that canton in the middle of July and dying out in August (Sobernheim and Novkaovie).

Information of the place of entrance into Spain is also rather indefinite. We are told that Barcelona was one of the cities attacked early. Barcelona is situated on the Mediterranean near the French border and is quite directly connected by commerce with Marseilles and other French ports on the Mediterranean.

In June the disease had also spread to Norway and outside of Europe to the West Indies, South America, India and China. A short notice in the Public Health Reports tells us that epidemic influenza with an estimated number of 1,500 cases began in Christiania, Norway, about June 15th.

Atiles relates that influenza appeared in Porto Rico in June, soon after the arrival of a ship from Spain. It spread rapidly, and it is estimated that at one time fully eight per cent. of the entire population had the disease simultaneously, and that forty per cent. of the population were affected during the epidemic.

The Health Officer at Bombay made report in July, 1918, on an influenza-like disease then spreading throughout India. It was stated that the disease was introduced into Bombay from overseas by a transport which arrived May 31, 1918; that by June 22d the disease had become epidemic at Bombay, and that it was present in July, 1918, at Calcutta and Madras.

The rapid spread from Europe to distant India may be accounted for with the same mechanism as that by which the disease was spread from America to France and from France to England, *viz.* by army transports. The occurrence of the disease in Porto Rico appears to have been definitely connected with the arrival of a ship from Spain. A very short notice in the Public Health Reports tells us that influenza was reported present at Santos, Brazil, June 16, 1918. We are not informed as to how it reached that place.

We have discovered no mention of influenza in China in June. It was reported present in Chungking, China, July 27th. and at that time one-half of the population was stated to be affected. Dengue was reported prevalent at Chefoo, China, during the two weeks ended June 15, 1918, and a report from Shanghai of the same date describes the prevalence of a disease resembling dengue and affecting about 50 per cent. of the population. The disease in these two latter places may have been influenza.

The epidemic made its appearance in Korea in September, 1918. Schofield and Cynn, who report the epidemic, believe that the infection came from Europe via Siberia. The disease spread from North to South along the line of the Southern Manchurian Railway.

In August the disease was re-introduced into the United States and by the end of that month it had acquired a foothold in Boston and vicinity and rapidly spread to other parts of the country. The pandemic had crossed the Atlantic in both directions in six months' time.

In 1918 as in 1889 there are excellent descriptions of the conveyance of the disease by vessels. The transfer from Spain to Porto Rico has been mentioned. Escomel says that the outbreak in Rio de Janeiro was ascribed to infection from a steamship from Spain, the same boat which later visited Buenos Ayres and started the epidemic in the latter city.

According to a report to the Journal of the American Medical Association from Mexico the epidemic invaded that country from the North at Laredo and followed the course from North to South. From a similar source the same Journal reports that the influenza spread from Buenos Ayres as a primary focus to Paraguay and there acquired greater virulence.

Hernando reports from the Philippine Islands that influenza was estimated to have attacked forty per cent. of the total population of 7,000,000 the mortality being about 2.5 per cent. of those attacked. The epidemic really began in June, although it did not assume great severity until October. The group of ages that suffered most were those between ten and twenty-nine years. The disease did not seem to be imported, since cases were returned before any ships arrived from infected countries, although after the importation of cases it assumed a more severe form. The June epidemic seemed to confer a certain degree of immunity during the second outbreak of the disease in October.

Erlendsson reports that the influenza when it appeared in Iceland in November, 1918, corresponded in character with that in other portions of the world. Macklin gives an interesting description of the epidemic as it occurred in Lapland. The onset in that territory was probably in November. He found that many individuals recovered in two or three days and were about their work again feeling perfectly well. If, however, they contracted pneumonia, about fifty per cent. died.

"The Laplanders had a very thorough if unsympathetic way of dealing with their cases. The settlements were composed of wooden huts, small but generally well made and warm. A common type consisted of but one room, used by the family for all purposes. Better class Laps had better huts, with two or three rooms. In each settlement one of the single-room huts had been set apart, and into this each case of sickness as it arose was unceremoniously pushed; and none were permitted to return to their own huts until completely recovered. Whilst there they received practically no attention, and no healthy person ever entered to attend to their wants. Occasionally a bowl of water or reindeer milk was hastily passed in at the door, or a huge chunk of reindeer meat thrown in, uncooked and uncarved.

"We visited every settlement within our reach and entered these huts. The stench on opening the door met one like a poison blast and the rooms were nearly always ill lighted and dark. The patients lay littered about the floor in a crowded mass, fully dressed in clothes

and boots (most of them had no socks), and with no other cover but an occasional greasy rug. Although the outside air was cold and the ground snow-covered, the temperature inside, maintained by the combined mass of bodies, was generally sufficiently high. The patients in these huts included both sexes and all ages; some, when we entered, sat up and with flushed faces and dull, uncomprehending eyes watched us listlessly. Others lay restlessly twisting about, quite incapable of taking any interest or of answering any questions."

The epidemic struck Alaska in October, invading first the towns of the sea coast, being very evidently brought thither by steamer. Travel to the interior was stopped and so the latter escaped, to a great extent, the outbreak. At Kodiak and on Cook Inlet, the mortality was extremely high. Whole villages of esquimaux lost their entire adult population. Many infants were frozen in their dead mothers' arms.

Influenza in China.—We have been able to follow the pandemic quite consecutively as it has spread around the world, from a first outbreak in the United States in March, 1918. We repeat that the disease was presumably present in Europe and elsewhere previous to that time, as it was in America, but the particular virus which ultimately acquired sufficient virulence to produce the pandemic may well be that which came from North America. Did this virus arise from an endemic focus in this continent, or was it transported to us at a somewhat earlier date from Asia?

McNalty states that influenza was present in China and in the Japanese Navy in March of 1918. He gives no reference. Carnwath makes the same statement and gives as reference the report of Kabeshima and Lee. The author has not been able to obtain this report.

The Health Officer of Shanghai made the following report for May, 1918: "Towards the end of the month, reports were received of outbreaks of 'fever' which rapidly affected a large proportion of the employees of various offices, shops, police stations, etc. As a result of clinical and laboratory observations of cases admitted to the Chinese Isolation Hospital the disease was recognized as epidemic influenza. The same disease was reported to have appeared in Peking before reaching Shanghai, but subsequent reports showed that most of the river ports were almost simultaneously infected; that is to say the rate of spread conformed to the rate of conveyance by railways and boats of infected persons;"

In November of 1918 an editorial note in the China Medical Journal reads as follows:

"From nearly all parts of China reports are being sent to the newspapers of the occurrence of a severe epidemic of disease which seems to manifest itself in various forms. In Wusueh, where the disease is called 'the five days' plague' the symptoms are said to be not unlike those of cholera, death in some cases ensuing in less than a day. In other cases it is complicated by severe and often fatal pneumonia. At Anking many cases have all the symptoms of typhoid fever, but the mortality is great and sudden. In one house four people died within a few hours of each other, and in another house eight persons out of eleven died. At Wuhu and other of the lower Yangtze ports it is said to resemble dengue fever and the mortality is so great that undertakers are finding it difficult to meet the demand for coffins. In Shansi, where the victims literally number thousands, the disease is regarded as influenza. In Peking fully fifty per cent. of the Chinese have been affected and the mortality has been heavy. Accurate reports from medical men in these cities would be very instructive."

The author has the following personal communication from Doctor Arthur Stanley of the Health Department of the Shanghai Municipal Council. "Influenza fever appeared during the recent epidemic in Shanghai towards the end of May 1918. It swept over the whole country like a tidal wave. You may take it that it spread like most rapid extant means of transit. A primary source of origin was not made known."

It is to be hoped that more definite and concurrent information will be forthcoming in the case of China. A thorough search of the literature as reviewed for China and Japan in the China Medical Journal reveals no description of the disease previous to April or May of 1918. Nevertheless we must assume that, until contradictory reports are made, the disease was present in those countries in March as stated by Carnwath.

Autumn Spread in the United States.

By the first of July, 1918, convalescent cases of influenza began to appear among members of the crews of transports and other vessels arriving in Boston from European ports. The number of such cases on each ship was usually not more than four or five, but Woodward records that in one or two instances between twenty and twenty-five individuals were sick on incoming vessels. None of these were seriously ill, none were sent to the hospital, and none died. The disease in this class of persons did not become severe until late August. Woodward has found on inquiry among practising physicians that

typical cases of influenza were seen with notable frequency in private practice in the vicinity of Boston during the month of August, and that they had developed no serious complications, the only after effect being the marked prostration.

These mild preliminary cases failed to attract attention; first, because of their relative scarcity, and second because of their benign character. Public attention was first directed to the influenza in Boston by the apparently sudden appearance during the week ending August 28th of about fifty cases at the Naval Station at Commonwealth Pier. Within the next two weeks over 2,000 cases had occurred in the Naval forces of the First Naval District. One week later there was a similar sudden outbreak in the Aviation School and among the Naval Radio men at the Massachusetts Institute of Technology. The first death in Boston was reported on September 8th.

The peak of daily incidence in Boston occurred around the first of October. In the week ending October 5th a total of 1,214 deaths from influenza and pneumonia was reported, while by the third week of October this total had fallen to less than 600, and for the week ending November 9th was down to 47. Around November 15th the number of cases rather suddenly increased and this recurrent wave lasted for about ten days. By the 25th the rate was back to what it had been around the first of the same month. On or about December 1st the incidence again rose and continued increasing daily, to reach its peak in a severe recrudescence around December 31st.

There are conflicting reports concerning the date of first appearance of the epidemic at Camp Devens, Massachusetts. Woodward says that a sudden and very significant increase was reported during the third week in August in the number of cases of pneumonia occurring in the army cantonment at Camp Devens, seeming to justify the statement that an influenza epidemic may have started among the soldiers there even before it appeared in the naval forces. Soper, on the other hand, as well as Howard and Love in their official report, place the date of the first case at Devens as September 7th. Soper remarks: "The Devens epidemic is supposed to have commenced on September 7, 1918, in D Company, 42d Infantry. On that date a case of supposed meningitis was sent to the hospital from this company; on the following day twelve cases were sent for observation. These proved to be influenza. By the 16th thirty-seven cases had gone from the same company." Howard and Love state, "The first authentic cases of virulent influenza of the great autumn pandemic among troops in the United States appeared on September 7, 1918, at Camp

Devens, Mass." These statements by Howard and Love do not eliminate the possibility of earlier and less virulent unrecognized cases. Wooley, who was camp epidemiologist, reports that influenza began at Camp Devens on the 8th of September, 1918. It reached its acme on the 16th, 17th and 18th of the month and then rapidly declined, almost completely vanishing about the middle of November. He makes no observation as to whether a mild form of the disease was or was not present in the camp in March and April preceding.

Influenza entered Massachusetts at Boston. Reeks reports that it entered Connecticut at New London, the cases coming primarily from the experimental station and from Fort Trumbull, where vessels from foreign ports had discharged patients. He believes that the disease was first introduced by ships arriving in New London from abroad and by men from the Boston Navy Yard, but numerous foci developed in a short period of time in various parts of the state. Many of these had appeared by the middle of September, and the source, according to Winslow and Rogers, was traced to military establishments, chiefly Camp Devens. In Wallingford, Willimantic, Hartland, Rockville and Danbury, all of which towns were attacked early in the epidemic, investigation showed that the disease developed in each case two or three days after visits of soldiers from Camp Devens. In Connecticut the epidemic spread, beginning at New London, chiefly from east to west, reaching its peak in the Eastern section around October 4th, in the central section October 15th, and in the Western part of the state around October 24th. Towns which had been infected early by visitors from military establishments reached the climax sooner than other towns nearby. In spreading from New London north and west the large cities of Connecticut were successively invaded, New Haven and Hartford reaching their crest about ten days later than New London, while Fairfield County did not reach its acme until later than New Haven.

In the cities along the New England coast we see then that the disease reached epidemic proportions early in September. By September 21st it had become epidemic in a wide area along the Atlantic coast extending from the Southern part of Maine to Virginia, as well as in a number of localities scattered over the entire country. By September 28th, areas adjacent to the centers in which the epidemic had already appeared were affected, suggesting radial movement from these centers. By that time the greater part of the New England States, the North Atlantic and Central States, and some of the Gulf and Pacific Coast States had become involved. By October 5th the pandemic had apparently reached all parts of the country with the

exception of the more isolated rural districts and some areas in the Central States and Mountain States. Within an additional ten days even these areas, with the exception of the very remote rural districts, had been reached by the epidemic. Within four weeks the disease had become distributed to all sections of the country, and within six weeks from its first epidemic prevalence in Boston practically the entire country had been invaded.

Sydenstricker in a preliminary report remarks on the fact that the disease reached an epidemic stage in a number of localities in the central, northern, southern and western sections at about the same time as it did in the area along the northeastern coast. "The possibility is suggested, therefore, that sources of infection existed in at least some of the larger population centers, well distributed through the country, some time before the disease appeared as a nation-wide epidemic. The apparent radial spread of the epidemic from certain centers would seem to strengthen this hypothesis. It may also be noted that there is evidence, the collection of which has not yet been completed, pointing to the existence of cases of the disease in various centers, probably widely distributed, weeks before they were definitely recognized as influenza. The possibility that these foci themselves had a common focus is by no means excluded, of course, but there is as yet no conclusive evidence that would warrant the statement that the starting point of the epidemic was Boston or any specific locality."

Dublin, from a study of the statistics of the Metropolitan Life Insurance Company, finds that the virulence of the influenza, as indicated by the mortality rate, was greatest along the Atlantic Coast and became progressively less as it progressed westward. There was one exception. The mortality was high in San Francisco, higher than in other western communities. Dublin believes that quite possibly there was a double infection in San Francisco in the fall of 1918, one coming from the East and of small caliber, while the other came either by way of the Panama Canal or perhaps from Asia. The evidence in favor of two ways is that Dublin finds that the peak of incidence in San Francisco and in some other places on the Pacific Coast occurred sometime in advance of the similar peak at points inland from the coast. This is not brought out in Pearl's chart, and the latter finds when considering the peak of deaths that the peak for San Francisco was late. The peak in that city, in Oakland, California, and in Los Angeles, was reached on the week ending November 2d. Few cities had as late death peaks. Cleveland and Pittsburgh reached their peak in the same week, St. Paul, Minnesota in the week ending November 16th, and St. Louis, Milwaukee and Grand Rapids not until

the week ending December 14th. In the case of Milwaukee and St. Louis these were the high peak dates but they were second peaks. In the former the first peak occurred October 26th and in the latter November 2d. In Grand Rapids the increase in mortality was clear-cut by the middle of October, although the peak was not reached until the week ending December 14th. These statistics would indicate that San Francisco was attacked, as evidenced by increase in death reports, relatively late, and at about the time that would be necessary for the disease to be carried across the continent.

In an article by Ely, Lloyd, Hitchcock and Nickson it is said that influenza first appeared in the Puget Sound Navy Yard, near Seattle, on September 17, 1918, and that it was introduced by a draft of 987 sailors received from Philadelphia, a number of whom arrived ill, or came down within a few hours after reaching their destination. As a result, Seattle and the State of Washington were infected somewhat ahead of the other West Coast States. According to the record, influenza did not assume epidemic proportions in the State of Oregon for nearly a month after this Navy Yard epidemic.

With army camps and cantonments situated in nearly every section of the country it is difficult to follow the general direction of spread from camp to camp. During the period of the epidemic, troop-movements were in general from West to East toward points of embarkation rather than in the reverse direction. This was in the opposite direction to that taken by the pandemic. Away from the coast there were, however, many movements of troops from camp to camp, in the redistribution of forces. That these troop movements were not discontinued during the epidemic is indicated by the report of Howard and Love: "The virulent type of influenza had spread rapidly from camp to camp, from the Atlantic seaboard to the South and West, due to the continual interchange of personnel from infected to non-infected camps. Such movements of troops at this time were recognized as dangerous and inadvisable, and prompt recommendations were made by the Medical Department that such movements be discontinued or greatly restricted, if compatible with military interests, which, of course, were at the time paramount. The War Department was unable to approve any marked restriction of movement of men from camp to camp at this time. One result of the free inter-communication of military personnel was that practically all military stations in the United States were in the throes of the epidemic at the same time."

In addition to this means of inter-communication we had the possibility of spread to the various camps by the ordinary course of civilian and commercial travel as in spread to different communities, and also

the possibility of importing large amounts of virus at one time on the incoming trains with new draft troops.

Soper gives the following order for camps attacked:

Order.	Camp.	Location.	Date.
1	Devens	Massachusetts	Sept. 12
2	Upton	New York	Sept. 13
3	Lee	Virginia	Sept. 17
4	Dix	New Jersey	Sept. 18
4	Jackson	South Carolina	Sept. 18
5	Hoboken	New Jersey	Sept. 19
5	Syracuse	New York	Sept. 19
5	Gordon	Georgia	Sept. 19
5	Humphreys	Virginia	Sept. 19
6	Logan	Texas	Sept. 20
6	Funston	Kansas	Sept. 20
6	Meade	Maryland	Sept. 20
7	Grant	Illinois	Sept. 22
7	Taylor	Kentucky	Sept. 22
8	Sevier	South Carolina	Sept. 23
8	Lewis	Washington	Sept. 23
8	Newport News	Virginia	Sept. 23
9	Pike	Arkansas	Sept. 24
10	Beauregard	Louisiana	Sept. 25
10	Eustis	Virginia	Sept. 25
11	Greene	North Carolina	Sept. 26
11	McClellan	Alabama	Sept. 26
12	Kearney	California	Sept. 27
12	Bowie	Texas	Sept. 27
13	Johnston	Florida	Sept. 28
13	Sheridan	Alabama	Sept. 28
14	Sherman	Ohio	Sept. 29
14	Dodge	Iowa	Sept. 29
14	Shelby	Mississippi	Sept. 29
15	Custer	Michigan	Sept. 30
16	Travis	Texas	Oct. 1
17	Cody	New Mexico	Oct. 3
18	Forrest	Georgia	Oct. 6
19	MacArthur	Texas	Oct. 7
20	Wadsworth	South Carolina	Oct. 11
20	Wheeler	Georgia	Oct. 11
20	Greenleaf	Georgia	Oct. 11

Howard and Love have established definitely that the extension of the virulent influenza from Camp Devens to other camps south and west in September, 1918, can be traced in many instances directly to the interchange of military personnel from infected to non-infected camps. The height of the September outbreak in the United States Army extended over a period of about nine weeks, from Sept. 13th to November 15th, and during this period over 20,000 deaths occurred among troops in the United States alone in excess of the number that would have occurred, if the disease death rate for the corresponding period of the preceding year had prevailed.

It is interesting to note with respect to Camp Humphreys, Virginia, that there were possibly some sporadic cases previous to the autumn outbreak. Brewer in reporting on the epidemic in September and October records the first case as having occurred shortly after July 1st. He makes no mention of there having been any outbreak whatever prior to that date. Between July 1st and September 12th there were only sporadic cases diagnosed as influenza. The autumn outbreak began at Camp Humphreys September 13th and ended October 18th.

Recrudescences.

We have already seen from the work of Pearl that recrudescences following the original spread in any one locality were the rule rather than the exception in this country. He found that in sixty-five per cent. of the forty cities studied there were two distinct peaks in the mortality curve and in twenty per cent. there were three, while only fifteen per cent. had but one peak. The first peak was as a rule the highest. Although there was no absolute regularity in the time of occurrence of the recrudescences, Pearl established that the high-peak cities had the second peaks on an average 7.1 weeks after the first, and the third peak on an average 13.1 weeks after the second. The two-peak cities are divided into two classes, the first comprising about a third of the total number, had the second mortality peak around eight weeks after the first, while the remaining two-thirds had the second peak about thirteen weeks after the first. The cycle in the epidemic wave appears to be nearly a multiple of seven weeks. He suggests that the smaller group of two peak cities with early second peak may have been cities which at the time were presumably destined to show a third distinct wave and peak of mortality, but in which for some reason not now apparent the third wave did not eventuate. In contradistinction the larger group of two-peak cities with the second peak

occurring around thirteen weeks after the first are presumably cities in which the complex of factors determining the form of the mortality curve was such as to lead definitely to a two and only two-peak curve. In three-peak cities the first interval was around seven weeks, the second around thirteen weeks. The two-peak cities with an interval around thirteen were probably not destined, according to Pearl, to have another repetition, but those with an interval of seven were presumably destined to have a second interval, the thirteen-week interval, which for some reason did not occur.

This raises the question of periodicity, a subject which we will discuss at a more appropriate place.

This experience of recrudescences was similar in the American Expeditionary Forces. The first outbreak lasted through April and May and into June. The second came in September and October. The spring epidemic had been characterized by mildness and was known as three-day fever, but in the autumn, complications of the respiratory tract predominated in the symptom complex. By August 18th a severe epidemic had occurred in an artillery camp at La Valdahon in the Jura Mountains, near Bezançon. Early in September a larger epidemic occurred in an artillery camp near Bordeaux. The epidemic in our troops in France, as well as in the French civil and military population, reached its height during October. The Service of Supply was more heavily affected than were the troops situated on the battle front. The morbidity rate appeared to have been almost the same as that in the United States. That it was not quite as high has been shown by Howard and Love. Longcope states that it prevailed particularly among the troops at the base ports where during a part of the epidemic transports laden with infected troops were being landed; in those organizations which contained the largest number of replacement troops; and in organizations being moved on troop trains, where the men were necessarily closely crowded.

The second outbreak subsided during the early part of November. A third occurred in January and February, very much as it had done in the United States. In the interval between the second and third recurrences there was no time at which the entire Expeditionary Forces were free from the disease. The author had occasion to study an outbreak occurring early in December in the 26th Division stationed in rest area at Montigny-le-Roi. In this outbreak the respiratory complications predominated, as in October, and the mortality was comparatively high. We had had occasion to study the same disease at Camp Sevier, South Carolina in September and early October, 1918,

and in two different localities in France in December, 1918, and February, 1919, and found that the clinical characteristics were identical on both continents.

The more severe recurrence in England, in October, has been carefully studied. In fact this recurrence was almost universal in all countries. The autumn epidemic has been reported as being at its height in October, 1918, in such widely separated localities as the United States, England, France, Greece, Brazil, India, Japan and Korea.

In Europe at any rate the third wave occurring in the winter of 1919 was quite generally distributed. At about the same time the disease broke out in England, making a third wave in less than a year. Once again the third attack began less suddenly and less violently and resulted in a lower number of fatalities. During February there was reported to have been a great increase in the number of cases in Paris. It had terminated by March 27, 1919. In March the disease broke out anew, this time assuming grave proportions, not only in that city but in several of the Departments.

The second recrudescence has also been reported as being present in Spain.

On May 5, 1919, report was received from Buenos Ayres that in one of the concentration zones for naval troops located in the harbor there had been an epidemic of short duration, but with high morbidity, with two hundred cases being frequently reported each day.

Just as Pearl has observed a certain periodic recrudescence in the United States, there has been described a similar periodicity in England. The interval, however, is described as twelve weeks. The first wave began in July and died down about the end of August, running a two months course. Twelve weeks after the commencement of the first wave, at the beginning of October, the second appeared. It had disappeared around the middle of December. Again, twelve weeks from the beginning of the second wave, that is, in January, the third appeared.

Recurrences in Winter of 1919–1920.

We distinguish between the flareups following the autumn spread of 1918, and which lasted until the spring of 1919, and yet another widely distributed recurrence in the winter of 1920. We have called the former recrudescences to distinguish them in point of time from the latter, but do not imply thereby any difference in the character or origin of the secondary waves. Between them all there occurred

almost continuously isolated or solitary cases of influenza which served to keep the fires smouldering. In our own work in the city of Boston we found record of scattered infrequent cases of clinical influenza of apparently low infectivity in every month from March, 1919, until the recurrence in January, 1920.

Moreover, in some localities there were during this interval small epidemic outbreaks. Thus a report from Lisbon, Portugal, on June 1, 1919, states that the deaths from influenza in that city during the preceding two weeks had been more than the total deaths from all causes during the preceding four months. A report from London, October 30, 1919, states that during the preceding few weeks there had been in the ninety-six great towns of England and Wales a slight but gradual increase in the number of deaths attributed to the disease, and a coincident rise in the number of notifications of acute primary and acute influenzal pneumonia. The feeling at that time was that the increase was associated with prevailing meteorological conditions, and did not apparently signify more than the usual variation in respiratory diseases which was to be expected at that season of the year. On November 3, 1919, the disease was reported prevailing at Chile and it was spreading throughout Boliva. At the same time influenza had spread over the entire country surrounding Buenos Aires and had even reached the neighboring city of Montevideo. In the latter part of November more than 2,000 cases had been reported at Lemaies, about fifteen miles northeast of Granada, Spain.

The winter of 1920.—In the United States the death rates from influenza and pneumonia in the large cities over the entire country were below the usual average from May, 1919, until January 1, 1920. In the week ending January 17th there was a sharp increase in the influenza-pneumonia rate, which occurred simultaneously in Kansas City and Chicago. In the latter city an excess over the average was not reached until some days later, but the maximum mortality occurred in the week ending January 31st, while in Kansas City the mortality did not reach its height until one week later. New York, Washington, San Francisco, Milwaukee and St. Paul soon followed with an increase in the week ending January 24th, and in the subsequent two weeks many other cities were added to the list. By February 14th thirty-two out of the thirty-six large cities reporting had an increase in the death rate from influenza and pneumonia as compared with the same period in 1917. The maximum was reached at this time, and according to the Bureau of the Census reports there were 7,059 deaths from influenza and pneumonia during the week ending February 14th. In

the next week the number of deaths from these causes in the cities reporting had dropped to 5,088. The February weekly average for 1917 was 1,489. In the week ending February 14th, 267,643 cases of influenza were reported from forty-one states; the excess annual death rate as compared with the average for the period from 1910 to 1916 was 1,319.

In general the 1920 recurrence was decidedly milder than the autumn outbreak of 1918. Certain cities, however, suffered severely, particularly Detroit, Milwaukee, Kansas City, Minneapolis and St. Louis. In these the death rate, while the epidemic lasted, was higher than that of 1918. The duration of the epidemic was generally, however, shorter in these cities. Columbus, Ohio, and Indianapolis suffered severely, but to a less extent than the cities just mentioned. In Chicago the death rate was not as high as in the fall of 1918, but it did rise far above the point reached during the 1889–90 outbreak, and the influenza in the last two weeks of January brought the total mortality for that month up to 5,149, the highest mortality in the history of the city with the exception of October, 1918.

We have already discussed the recurrent epidemic as it was studied in Detroit. The salient characteristics were a rapid and fairly symmetrical evolution, a shorter duration than in 1918, a lower morbidity with a higher mortality rate, and finally, a smaller total number of deaths than in 1918.

The 1920 recurrence was widespread. It was not confined entirely to the large cities. Semi-official reports from small towns and villages show very much the same conditions as were observed in the larger cities. On the whole, however, most communities, both large and small, suffered less severely than in the first spread. The few exceptions to this were distributed over the continent without uniformity.

The first among the large cities to show an increase in death rate from the epidemic was Kansas City, in which the mortality first climbed in the week ending January 17th. The following week there was an increased rate in Chicago, New York and Milwaukee, and one week later, Boston, Detroit, San Francisco and Philadelphia were affected. New Orleans was one of the last large cities affected, not showing a definite increase until the week ending February 14th. In contrast to the 1918 pandemic, the influenza of 1920 showed no clear-cut direction of spread, and was as in the years following 1889 due, without doubt, to firing up of the pandemic virus as it had been left scattered in many endemic foci throughout the earth. There probably

were instances of spread from the larger centers to outlying districts, but there was no continuous spread over large areas. The accompanying table shows clearly that the disease this year commenced in the center of the continent, a fact which would seem to disconnect it entirely from the late epidemics of 1919, occurring in Europe:

Annual death rates from all causes by week in certain large cities of the United States from week ending January 3d to week ending February 21st.

City.	Week Ending							
	January.				February.			
	3	10	17	24	31	7	14	21
Kansas City	16.3	15.8	19.3	32.7	39.5	61.5	44.0	29.1
Chicago	14.4	13.8	15.1	23.5	41.3	39.1	24.6	17.7
New York	14.0	15.3	14.6	19.5	28.0	35.0	35.1	24.8
Milwaukee	11.6	12.5	9.0	15.6	29.4	34.5	27.1	16.9
Detroit	13.7	13.0	14.2	15.5	33.9	60.9	42.9	21.6
Boston	16.8	16.9	14.1	16.8	20.3	27.1	33.7	32.1
San Francisco	16.5	15.4	19.6	19.2	22.9	25.2	31.8	28.8
Philadelphia	15.6	16.7	16.2	16.8	18.3	22.1	34.3	37.2
New Orleans	18.8	19.6	22.6	18.8	20.9	20.1	25.0	32.3

The relative severity of the two epidemics in certain of the large cities has been compared by H. F. Vaughan, and he has found as is seen by the table that Kansas City and Detroit, two of the early cities affected, had the highest mortality in 1920. Philadelphia in 1918 lost nearly three times as many people as Detroit did in 1920. Detroit was higher than Chicago in 1920, but lower in 1918.

Per cent. of population killed by influenza.

	1920.	1918–1919.	
	First seven weeks.	First seven weeks.	Twenty-one weeks.
Detroit	0.20	0.17	0.28
Chicago	0.12	0.34	0.41
Kansas City	0.24	0.30	0.63
Philadelphia	0.10	0.76	0.82
New Orleans	0.05	0.55	0.77

The following table taken from the "Final Influenza Bulletin," by E. R. Kelley, Commissioner of Health in Massachusetts, shows distinctly the difference that must be always borne in mind between curves of influenza incidence and death curves. In his table the mortality climbed first on the week ending January 13th, as in the table

above, but the increase in influenza cases began at least one week earlier. It is characteristic of influenza epidemics that the rise of mortality curves follows that of morbidity by about a week:

Influenza and pneumonia cases in Massachusetts in the first three months of 1920.

	Influenza.		Lobar pneumonia.	
	Cases.	Deaths.	Cases.	Deaths.
Week ending January 3d	41	0	109	9
Week ending January 10th	46	2	142	50
Week ending January 17th	58	0	145	52
Week ending January 24th	489	4	201	56
Week ending January 31st	4,495	48	313	96
Week ending February 7th	9,627	272	382	212
Week ending February 14th	10,747	133	583	140
Week ending February 21st	5,601	181	510	147
Week ending February 28th	2,375	147	313	114
Week ending March 6th	1,144	54	206	34
Week ending March 13th	490	31	130	54
Week ending March 20th	254	20	105	44
Week ending March 27th	147	14	102	94
Week ending April 3d	218	6	97	12

In Massachusetts in the first three months of 1920 there were reported 35,633 cases of influenza and 3,158 of lobar pneumonia, with 906 deaths from the former disease and 1102 from the latter. The case rate per 100,000 from influenza was 883.4; from lobar pneumonia, 78.3; the death rate from influenza, 22.4; from lobar pneumonia, 27 .4; and the fatality per cent. from the former disease was 2.5, and from the latter, 34.9.

The epidemics in Detroit and Boston both showed a symmetrical evolution and a single wave. This appears to have been the more frequent type of recurrence in this country. There are examples of the secondary curve. At the Great Lakes Naval Training Station the epidemic began during the week ending January 17th. On January 12th there were fifty-one cases. The peak was reached on the third day with the admission of 182 new cases during twenty-four hours. Although the peak came early the decline was less rapid and there were four secondary peaks, but the outbreak terminated on the twenty-fourth day. On the whole the epidemic was less severe than in 1918. Pneumonia was a complication in about ten per cent. of the reported cases of influenza at the training station.

On the European continent there were similar recurrences in the first three months of 1920. In the large towns of England the recorded

deaths from influenza made an increase in a steady curve from sixty-six in the last week of January until the week ending March 27th. After that date there was a gradual falling off. That the situation was in no way as serious as it was at the same time in the American cities and in certain other parts of Europe is indicated by an annotation in the Lancet of March 6th. According to this annotation, the weekly totals of deaths attributed to influenza in London and the 96 great towns had on the whole tended to increase in the early part of 1920, but the absolute increment was so small and the necessary uncertainty of classification so great that no unfavorable inferences could be drawn from these fluctuations alone. On the other hand, the notifications of cases of pneumonia increased appreciably, too much to be set down as a mere chance fluctuation. But notification for this disease had not been in force long enough to enable accurate comparison. There were no indications of epidemic influenza in any of the large factories situated throughout the country. But on the other hand there was proof of the existence of epidemic influenza of an infectious, but relatively non-fatal type in certain large schools situated in the South and Southwest of England.

The annotation concludes that influenza was epidemic in a few localized English and Welsh communities, and that the type was similar to, but less severe than that of 1918–19.

In the city of Paris between the 11th and 31st of January there was a very definite increase in the death rate from inflammation of the respiratory tract above the average for other years.

Renon and Mignot studied 141 cases of influenza (71 men and 70 women) during January and February, 1920, at L'Hopital Necker. Fifteen of the 141 died. According to these observers the grip of 1920 attacked all ages in contradistinction to the 1918 epidemic which affected especially the young and vigorous. One-third of their group were over forty years of age, while some were seventy and eighty years old. In spite of this the disease remained relatively mild. Sixty-four were cases of simple grip. Forty-three had associated bronchitis and pulmonary congestion and edema. Twenty-seven had pneumonia. One had acute pulmonary edema. There were cases of influenza in tuberculosis individuals. One developed an acute serofibrinous pleurisy. One had purulent pleurisy, and one meningitis.

In Copenhagen there occurred between the 18th and 24th of January, 1920, 1,204 cases of influenza with four deaths; in the following week, from the 25th to the 31st of January, 7,445 cases with forty-two deaths; from the 1st to the 7th of February, 11,038 cases with 207

deaths; from the 8th to the 14th of February, 8,308 cases and 327 deaths. This is to be contrasted with the month of December, 1919, in which there were 1,845 cases of influenza in Denmark, of which only 272 were at Copenhagen. In Christiania, Norway, during the week of January 25th to 31st. there occurred eleven deaths from influenza, whereas during the preceding two weeks there had not been a single death from this disease.

In December, 1919, there were reported in Switzerland only 511 cases of influenza. During the month of January, 1920, this increased to 13,162, and in February to 83,008, the estimated population being 4,000,000. From February the disease decreased in prevalence. In Zurich, with a population of 210,000, the epidemic resulted in 14,534 cases. The first increase began around January 4th. The total number of cases for January was 1,071. In February the records of the four weeks showed 2,721, 4,140, 3,341 and 1,899 cases, respectively; in March the decrease was rapid, 886, 442 and 45 cases being reported in the first three weeks. The total number of deaths, mostly due to pneumonia, was 229, a mortality of 1.5 per cent.

During 1920 epidemics were also observed in Valencia, Santander and other towns in Spain, and in Mexico City. In the latter city the number of deaths was reported as 1,649, as contrasted with 3,000 in 1918.

Incubation Period.

An accurate determination of the period of incubation in influenza presents great difficulties. The large number of cases with the consequent multiple opportunities for infection in the case of every individual add to the difficulty. Under any circumstances the period is very short. Parkes, many years before the 1889 epidemic, believed that an incubative period sometimes exists; that it was sometimes very short and sometimes of many days duration.

"In the Transactions of the College of Physicians it is stated that in the epidemic of 1782, seventeen persons came to London to an hotel, and on the following day three were attacked with influenza. Haygarth says that a gentleman came to Chester from London, on the 24th of May, 1782, ill of influenza; a lady, into whose family he came, was seized on the 26th, and was the first case in the town. Haygarth states, evidently with the view to point out the possibility of a direct contagion, that the gentleman was engaged to be, and was afterwards, married to this lady. In this case the longest possible incubative period was two days. In 1782 a family landed at Harwich,

from Portugal, and came to London directly; the day after their arrival the lady, two servants and two children were all seized. Two men-of-war arrived at Gravesend from the West Indies; three Custom-house officers went on board; a few hours afterwards the crews of both vessels were attacked. Some other cases are on record where the incubative period, if it existed, could not have been more than a single day. On the other hand, some cases are on record in which the incubative period must have been two or three weeks."

Leichtenstern believed that the usual incubation period is from one to three days although some cases have been reported in which it is without doubt no longer than twelve hours. Parsons in reporting for England also gives the incubation period as from one to three days as a rule.

It is reported in France in 1918 that in one institution thirty-one cases out of thirty-three individuals occurred within three days, all of them infected by one nurse.

MacDonald and Lyth report in the British Medical Journal for November, 1918, an interesting observation concerning the incubation period in influenza. These two individuals were traveling from London to York in the same compartment with an individual who was just convalescing from influenza. Exactly forty-one hours after being on the train with this individual, they both came down with the disease. One suffered lightly while the other was severely ill. The wife and two children of the latter contracted the disease in turn, and with them also the first symptoms appeared suddenly after a delay of about forty-eight hours.

Stanley, in studying the epidemics of influenza in San Quentin Prison, found that as a rule there was an increase in incidence following the Sunday picture shows. This usually occurred on Tuesdays and Wednesdays, giving an apparent incubation period of from thirty-six to sixty hours. He tabulated the records of twenty-nine individuals who had presumably become exposed at the show and found that the incubation period averaged about forty-eight hours.

The majority of observers give the incubation period as from twenty-four hours to four or five days, most often two or three days.

Predisposing Causes.

Not every individual acquires influenza. There are those who assume that the disease is so wide spread that every individual in each community attacked has been actually exposed to the disease. In that case there must be a certain amount of natural immunity which

protects around sixty to eighty per cent. of most populations from the disease. The other extreme would be that every exposed individual falls victim to the disease and that only twenty to thirty or forty per cent. are actually exposed. The true state probably lies between these two extremes.

Nevertheless it is a fact that some individuals naturally insusceptible to the disease fall victim as a result of the action of some extraneous force, something which lowers their resistance. Raw recruits in the army camps in the fall of 1918 contracted the disease in much greater proportion than did the hardened soldiers. Fatigue, intercurrent illness, environmental changes and exposure to inclement weather may all predispose to infection in the individual. Greenwood found that the compulsory rationing of food in England during the war was probably not a predisposing cause of infection. The incidence of the disease in the South Africa Union where food was abundant was even higher than that for the British Isles. Hamer calls attention to the fact that the ages of highest incidence during the pandemic were those ages in which the diet was perhaps more restricted than in other ages. This, however, is but one factor and cannot be accepted as conclusive.

It had been suggested that in the army camps in the United States typhoid vaccination during the epidemic predisposed to the disease. The similarity of the symptoms in vaccine reaction and in influenza may have suggested this. V. C. Vaughan has investigated this possibility and finds that those organizations in which anti-typhoid vaccine was discontinued for a time after the appearance of the influenza suffered quite as severely as those which submitted to vaccination.

Other predisposing causes, such as the incidence of crowding in a household and the sanitary surroundings of the individual will be discussed later.

Periodicity.

The phenomenon of occurrence of epidemic influenza in many countries, even on different continents almost simultaneously and often without any clear-cut progressive spread from one of these countries to another raises the question of periodicity in influenza. Is this simultaneous occurrence due to some mechanism in the life cycle of the influenza virus whereby it regularly acquires increased invasiveness, no matter what its geographical distribution, or is it merely a feature of the meteorologic conditions that makes the epidemic appear to be simultaneous in widely scattered communities?

Influenza characteristically returns. An influenza period usually

comprises from three to five years, with one or two very mild epidemics at the beginning which may frequently be overlooked, then of wide pandemic spread, to be followed by endemic recurrences for as long as two or three years. During these influenza periods the intervals between waves are frequently so nearly equal or multiples of each other as to force the question of a periodic law. Not only thus, but even on a larger scale does the disease appear with a certain uniform regularity. The great epidemics are separated frequently by intervals approximating decades. Stallybrass calls attention to the epidemic years in England, which are 1789–90, 1802–03, 1830–32, 1840–41, 1848–49 and 1851, 1854, 1869–70, 1879, 1890–91, 1898, and 1918–19. With the exception of 1854 all of these dates are around the end of a decennium.

Yet, again, in the successive waves of an individual epidemic, as has been pointed out by Pearl, there is very roughly some periodicity.

Are these admittedly obvious phenomena fundamental features of the life cycle of the influenza virus, or are they incidental, due to extrinsic causes, changes in the pabulum, in the host as an individual, or in the host as a community, or changes in climatic conditions? Is it a basic feature upon which we must build our conception of the epidemiology of epidemic influenza, or is it more a feature of chance? The evidence to date is conflicting and incomplete. The answer lies in the future.

Periodicity in the acute infections is not a new subject. It has been discussed in various other diseases, particularly in measles. For many years epidemiologists in many parts of the world have reported the observation of a periodicity in epidemics of measles. It is generally regarded as an established fact that each locality suffers from epidemic waves of this disease and that the period is somewhere about two years. In certain relatively small localities in England where registration statistics have been kept for many years the Health Officers count on an epidemic every two years. In some places the epidemic is expected to fall during the even years, while in others it occurs in the odd years.

Brownlee has been one of the foremost investigators in the periodicity of influenza, but since his communication on that subject was very brief, we take occasion to quote first from his article on the periodicity of measles, thereby gaining a more comprehensive knowledge of his theory, and at the same time becoming able to compare the periodicity in the two diseases.

"The common explanation of the periodicity of epidemics of chil-

dren's diseases is that the susceptible children take the disease in sufficient numbers to limit the further spread. The epidemic thus dies out to recur when a further sufficient number of susceptible children have accumulated. This is quite a feasible theory and certainly explains the periodicity of epidemics. The forms of epidemic curve which arise on this hypothesis are not unlike those actually found, the differences being no more than might be expected between a mathematical form based on a hypothesis and the natural conditions to which the hypothesis is only an approximation. This explanation, however, must fail if epidemics of different periods can be shown to exist in the same town at the same time, and I think this has been shown. In London, which on account of its size might be assumed deserving of special treatment, the existence of periods of different length have been demonstrated. In Edinburgh, Glasgow, and Birmingham also it has been shown that epidemics with periods in the neighborhood of ninety-eight weeks and one hundred and ten weeks intermix. The same epidemicity even applies to districts in London. In the West end of London we have almost a replica of what occurs in Glasgow, Birmingham and Edinburgh. The main period there is 97 weeks, the secondary period 109.5 weeks. In the South of London one period is that of 97 weeks, but almost equally prominent is that of 87 weeks. The whole evidence, therefore, seems to point to some condition in the organism which produces the disease as the potent cause of the difference rather than to the number of susceptible children. Compare the *Paramoecium* which under natural conditions divides asexually for several hundred times and then dies out unless conjugation takes place. The resting stage following conjugation persists for some time.

"There is, however, one point of great importance which must be considered. If an epidemic begin in a definite locality and spread from that locality, and if there is no loss of infectivity on the part of the organism, it is demonstrable that a similar proportion of the population should be attacked in each zone as the epidemic spreads outward. On the other hand, if the organism lose the power of infecting with the lapse of time, in each additional zone invaded the proportion of susceptible persons infected should become smaller and smaller. Of course this might not be true for any one epidemic, as in many parts of the area invaded the population might be more or less susceptible because of recent attack of the disease, but when an average of twenty outbreaks has been taken this effect should be eliminated, the number of times the invading organism comes into contact with an

insusceptible population being balanced by the number of times which it meets one more susceptible than the average. The method of spread of epidemics on the average should thus give some indication regarding the laws which determine the course of the phenomenon. Now with regard to London, the clearest facts refer to the 87-weeks, the 97-weeks and the 109.5-weeks period. The 97-weeks period starts at the same time all over the city and there is no evidence of any special center. The infection seems generalized. With regard to the 87-weeks epidemic, however, the case is different. This seems to start in St. Saviour's Parish and to spread thence to Camberwell, Lambeth, etc. In this epidemic the rate of spread can be definitely measured. The maximum occurs later and later as the distance from the center is increased and the percentage of children infected is also easily observed to fall as the time increases. With regard to the 109.5-weeks' period epidemic the facts are similar though not quite so definite. This seems to show that for at least two strains of organisms the epidemic ceases because the organism has lost its power of infecting. It may be inferred that an epidemic ceases because the organism varies in its potency to cause infection. A cycle of epidemics now coinciding and now differing in their maxima can thus be explained. Some kind of life cycle exists in the infecting organism. In this life cycle high powers of infecting are attained probably after a resting state: a period of activity follows and gives place to a period of rest; the average length of the cycle is determined by the strain of the organism."

There are certain drawbacks to Brownlee's work and conclusions. We quote from V. C. Vaughan, who has discussed Brownlee's work, not only because of his good summary of the difficulties and disadvantages of the method, but particularly because the same disadvantages and possibility of inaccurate conclusions hold in the case of influenza.

"There is no reason for supposing that the virus of measles is controlled in any way by our calendar. In order to get anywhere in determining any law of periodicity in epidemics we must know the morbidity and mortality of the disease by days, or at least by weeks. In different parts of a large city there may be, and undoubtedly are, epidemic waves of measles on the flow or on the ebb at the same time. The best work that has been done along this line is that of Brownlee, who has figured out epidemic waves of measles, based on the weekly numbers of deaths in London between 1840 and 1912.

"The figures presented by Brownlee are of great value, and his

theory is fascinating and has much in its favor, not only in a study of epidemics of measles, but of the other infectious diseases of infancy and childhood, especially scarlet fever, whooping-cough, and chicken-pox. In order to solve the problem of periodicity in measles we must have more exact information than we now possess. Brownlee's figures pertain to deaths only. There are, so far as we know, nowhere in the world satisfactory statistics concerning morbidity in this disease. Deaths from measles are so largely determined by the care bestowed upon the sick and upon the extent to which secondary infection is prevented that we are inclined to hesitate about the acceptance of a death rate or number of deaths from this disease as an index to the virulence of the organism causing the disease; in other words, we are not convinced that the death rate in a given outbreak of this disease is a measure of the virulence of the organism causing it. This involves the question whether measles *per se* is a disease of wide variation in malignancy or are the widely different death rates observed in different epidemics due to secondary infections. The streptococcus, a common invader of the body during the progress of a measles infection, is known to possess a most variable degree of malignancy. We are inclined to the opinion that if all cases of measles could be recognized before secondary infection occurs and could be cared for ideally the death rate from this disease in different epidemics would be much more uniform than is now shown and would be low. The greatest danger to life in an attack of measles lies in the fact that the virus lowers the resistance of the body cells and opens gateways to more deadly organisms, such as the streptococcus. We believe that there are demonstrated facts which support these ideas. Quite uniformly in measles there is a well marked leukopenia. As we now interpret it, this means a decrease in the number of the forces that naturally protect the body against the invasion of foreign cells. Again as we interpret it, the failure of the body cells to respond to the tuberculin test during a course of measles or soon thereafter is evidence that the resistance of the body is lowered. If our interpretation on these points be correct we fail to see how deaths from measles can be properly employed as a standard in the measurement of the virulence of the organism of the disease."

Recognizing then the obvious disadvantages of the method, we will turn to the work done on periodicity in influenza. We should call attention at this point to the fact that the establishment of periodicity would carry with it the assumption that the third of our three hypotheses concerning the origin of influenza is the correct one. For

example, the July and autumn epidemic in England, as well as all occurring subsequent to them, would be due to a virus or several viruses which have been endemic in England since 1889, in fact since man has been in England, and the epidemics and their recurrences would be due to increase in the virulence of this local virus. The virus is distributed over the earth and may become virulent periodically in many countries at the same time, or if the periodicity is different on two continents the epidemics would occur at different times.

Periodicity is not a new hypothesis. Hirsch denied any periodicity distinct enough to be revealed by the comparatively crude statistical methods of his time. Periodicity if present can only be revealed by detailed and complicated mathematical procedures. Brownlee has investigated the weekly number of deaths from influenza in London between 1889 and 1896, and also up to the present time. He has compared these with the weekly number of deaths from bronchitis and pneumonia in London, the records of which have been available since 1870. By the method of the periodogram he showed that there was a regular periodicity of 33 weeks in deaths from influenza between the years 1889 and 1896, but that in later years there was some considerable aberration. He concluded that for some reason influenza periods tend to recur at 33-week intervals after the primary epidemic, and that the favorable season for its recurrence is from January to the end of May. Should the 33d week fall in other than these winter months the epidemic may be mild or even missed, appearing after another 33-week interval. Epidemic influenza does not assume a form which causes any large number of deaths until a bronchitic or pneumonic constitution has been established. The fatal form is usually a disease of the winter or spring. He also found that in the absence of influenza, bronchitis and pneumonia did not show a 33-week periodicity, but when associated with influenza these conditions also became periodic (33 weeks), and he assumes that this change is definitely associated with the appearance of influenza.

Between 1876 and 1890 there was no tendency to the 33-week periodicity with regard to bronchitis and pneumonia, but it was very marked between 1889 and 1896. During this epidemic period the deaths from pneumonia precede those from influenza by one week and those of bronchitis precede those of influenza by two weeks. The number of deaths from bronchitis and pneumonia ascertained by this method of grouping is fully twice the number obtained from influenza alone.

He believes that in these years, influenza appeared, on its epidemic onset, first with bronchitic symptoms, later with pneumonic symptoms, and lastly with those symptoms more definitely associated with influenza proper. When the several sets of deaths are added together in 33-week periods a very typical epidemic makes its appearance.

Brownlee finds that in the monthly statistics of Glasgow, Aberdeen, Massachusetts, etc., there has been nothing differing essentially from this phenomenon found in London.

Between 1876 and 1889 the annual curve for bronchitis and pneumonia shows two maxima, one at the end of January and the second in the middle of March. From March the decline in deaths from bronchitis is very rapid. The disease re-appears around the beginning of October. During the period 1889–96 the maximum number of deaths from bronchitis occurred in the second week of January and the last week of February. Both of these maxima are a fortnight before the maxima of the epidemics of influenza. This suggests that the advent of influenza has brought a change in the seasonal prevalence of bronchitis and supports the view that the earlier portion of the influenza epidemic is associated with bronchitic symptoms. The same phenomenon holds for pneumonia.

Brownlee was able to predict correctly the date of the recent 1920 epidemic. He did not attempt, however, to explain the short interval between the summer and autumn, 1918, epidemics in England. He speaks of the second as "aberrant." In other words, it does not fall within his classification. October is not a high respiratory disease month. The epidemic should have been mild.

Stallybrass has confirmed Brownlee's 33-week periodicity and suggests an explanation for the "aberrant" October epidemic. Using periodograms with a 33-week basis, and plotting deaths from influenza and respiratory diseases from January, 1890, through January, 1920, he finds that the most definite 33-week periodicity is shown during the years 1890–99. During this period there is one maximum, when all 33-week periods are superimposed, which occurs at the seventh week of the cycle. Beginning about 1899 a new maximum appears in the nineteenth week of the cycle, which continues to recur until the culminating point is reached in the week ending October 26, 1918. An additional 66 weeks carries the date forward to the first week in February, 1920. The maximum at the seventh week of the periodogram during the years 1899–1913 is greatly diminished from that in 1890-98. The periodogram for 1914–1919 shows clearly both maxima, that in the seventh and that in the nineteenth weeks.

We quote Stallybrass in some detail (see Chart XII):

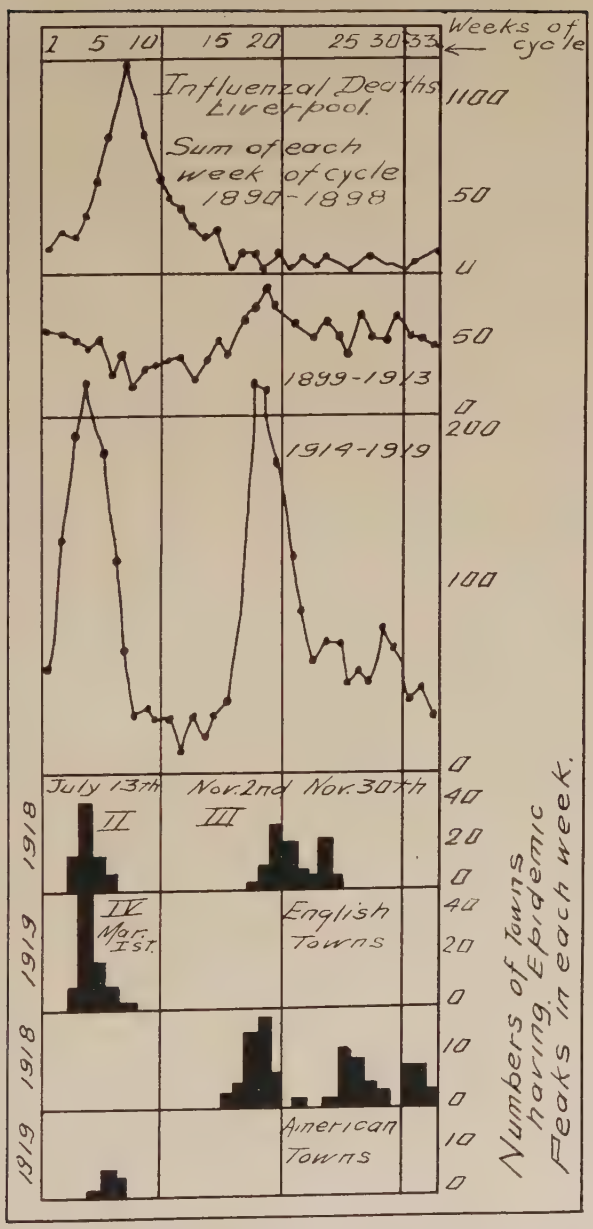
"Dr. John Brownlee pointed out that from July 13th to March 1st (the maxima of the summer wave of 1918 and of the spring wave of 1919) is 33 weeks, but that the wave having its crest in this country on November 2, 1918, does not fall into the sequence, leaving one to infer that there were two strains of the influenzal virus in operation.

"I supplement his investigation by the weekly deaths occurring in Liverpool during the period 1890–1919 that were ascribed to influenza and to all respiratory diseases. Prior to 1890 there were no deaths attributed to influenza for a number of years.

"Closely corresponding with Brownlee's observations on London by far the most definite periodicity is shown during the years 1890–1899, during which period there is one well-marked maximumy at the seventh week of the cycle. During the period 1899–1913 a new maximum in the nineteenth week of the cycle comes into play and continues to recur until the culminating point is reached in the week ending October 26, 1918, a week earlier than in most English towns (Wave III); a further 66 weeks carries one forward to the first week in February of this year, as Brownlee pointed out, and the outbreaks that are being reported in Japan, Paris, Chicago, New York, etc., would show that this strain has punctually reappeared.

"There is also evidence in the table of a small maximum at the twenty-seventh week of the cycle in the earlier sub-period, and at the twenty-ninth week in the later sub-period; slight movements of the maxima forwards or backwards in the cycle over a number of years may, perhaps, indicate a periodicity slightly greater or less than 33 weeks. The twenty-ninth week of the cycle fell on the weeks ending May 18, 1918, and January 10, 1919. An examination of the figures in Dr. Hope's annual report for Liverpool for 1918 shows that there was a definite wave of influenza reaching its crest on May 18th (Wave I), and there is also a definite rise in the deaths from influenza, respiratory diseases, and from all causes, making a small peak in the week ending January 3, 1919, but it is hidden by the enormous waves of October and March, so that it only appears as an irregularity in the curve; but it was noted at the time that influenza had not declined in Liverpool in January in the way that it had in practically all other English towns. These two waves do not appear to have played a large part in this country, but the outbreaks in the Grand Fleet in May, 1918, and also in Spain, Glasgow, etc., may, perhaps, be attributed to it. In the United States in January, 1919, it would appear to have played a much larger part. In a large number of American

CHART XII.



Periodogram based on the weekly influenza deaths in Liverpool between 1890 and 1919. The curves are based on a thirty-three week periodicity. (*Stallybrass.*)

cities two waves are experienced, the first being the October wave; the crest of the second wave sometimes fell in March, as did one of the crests in this country, but in a number of instances, *e.g.*, Cambridge, Washington, San Francisco, New Orleans, etc., it fell in January, or to be exact, in the thirty-first and thirty-second weeks of the cycle. The close relationship of Liverpool and Glasgow with the United States through the incoming stream of American troops may perhaps account for the presence of this May wave in these two towns, and not the rest of England.

"The third maximum in the fourth week of the cycle is represented during the late outbreak by the waves culminating in Liverpool, and also the greater number of English towns on the weeks ending July 13 (Wave II) and March 1 (Wave IV). This is a 33-week interval. This wave recurred at an interval of 32–34 weeks in a large number of English towns.

"Of 65 towns which experienced all three waves 47 (72 per cent.) had their maxima in the summer and spring epidemics within an interval of 32–34 weeks; but comparing the week in which any given town had its epidemic peak in the summer and autumn, and autumn and spring epidemics only 27 (41 per cent.) and 31 (47 per cent.) respectively fell within the limit of a week on either side. The time relationships of the maxima in summer and spring were much closer to each other than they were to the autumn maxima.

"If it should prove correct that there were three strains of the influenzal virus, each with a periodicity of about 33 weeks, and that simultaneously all three strains became enhanced in both virulence and infectivity, then we are faced with a phenomenon without an exact parallel, although the behavior of the meningococcal viruses during the war presents some points of similarity. So far the weight of evidence leans to such an exaltation of a widespread endemic strain or strains rather than to dissemination from any particular focus in the world. In any case doubtless a good deal of spread of infection took place."

Spear takes exception to the work of Brownlee and Stallybrass, and points out that the periodogram is not applicable to the study of recurrent epidemics unless the recurring waves are of approximately uniform "amplitude." In that case nothing could be less appropriate for this study than the influenza waves which vary from very small to extremely high, as in 1918.

Spear describes two simple tests which he applied to demonstrate the existence or non-existence of periodicity.

First he divided each of the last thirty years into 13 four-weekly periods, and tabulated the frequency with which the observed week of maximum mortality falls into one or other of the 13 groups. He discovered that the climax of an influenza prevalence falls more frequently in the second and third four-weekly period than in others—*i.e.*, the months of February and March. Had there been a 33-week periodicity there would have been an equal number of these climaxes in each of the 13 divisions of the year.

Brownlee, according to Spear, was correct in his prediction that influenza would occur in February, 1920, for the reason that January or February is the most likely time for an influenza prevalence in any year.

Spear's second test of periodicity consisted in plotting the interepidemic periods according to the number of weeks intervening. Were there a 33-week periodicity, he says, that nearly all interepidemic periods should fall in this group. As a matter of fact, more than twice as many periods fall in the 42–58 weeks interval than in any other interval. Fifteen fall within this period, six in the period 59–75 weeks, five in the period 8–24 weeks, and only four in the period 25–41 weeks. There was one in the period 76–92 and one 110 plus. Finally in the thirty years 1890–1919 there were thirty-two climaxes or peaks in the "influenza" mortality.

Spear concludes that if there is any periodicity it is around fifty weeks, or a year.

The fallacy in the work of Stallybrass and of Brownlee, according to him, is that the mortality in the third week of 1892, the twentieth week of 1891, and the tenth week of 1895, and in the big epidemic of 1918 so overshadowed all the other peaks that the smaller ones became lost in these larger waves.

Brownlee does not claim a 33-week periodicity during interepidemic periods. This part of Spear's criticism is not valid.

Vaughan's objections to the conclusions on measles hold equally well with regard to influenza. Finally, we must remember that in parts, at least, of the work of Brownlee and Stallybrass, they are not studying chiefly influenza deaths, but deaths reported as due to bronchitis and pneumonia.

After a study of the pros and cons of the question of periodicity the author submits by way of summary his conclusions:

1. Influenza does tend to recur at intervals. It has not been proven that these intervals are always of equal length.

2. At the present the opinions concerning the periods are diver-

gent. We have the 33-week periodicity of Brownlee and Stallybrass, the one-year period of Spear, the seven-week intervals suggested by Pearl, and the apparent twelve-week recurrences in England in 1918 and 1919.

3. It is to be noted that particularly in the work of Stallybrass, in order to prove his periodicity, he finds it necessary at times to quote epidemics occurring, not in England, but in fairly remote parts of the world, as in the United States and Japan. We have shown that in the interval between 1918 and 1920 an epidemic could be discovered somewhere on the earth in many months, perhaps even in every month during this interval. It is to be regretted that following the criticism by Spear there has been no further report, so far as we know, by either Brownlee or Stallybrass.

4. It is quite possible, even probable, that influenza is endemic in mild form throughout the inter-pandemic years in England, as well as in many, or all other countries, but it is equally possible or probable that the particular virus which gave rise to the pandemic was not one which simultaneously increased in virulence in all countries, but was one which had its origin in one comparatively well localized focus.

5. Our own theory does not explain the autumn recurrence in 1918 in England, following that of May, June and July. We have traced the original spread to England and have left it at that point. We have again taken it up in the autumn when it became severe, and was returned to the United States. The interval of quiescence in England and elsewhere may need further explanation. Two alternative hypotheses suggest themselves: First, that the autumn recrudescence is entirely comparable to later ones, and is but a manifestation of the characteristic feature of recurrence in influenza. Had the autumn epidemic been mild and had it not so overshadowed all others, we would have classified it with those of early 1919 as being merely recrudescences of the summer spread. Evidence, particularly in favor of this, is the report of Greenwood previously mentioned which shows that in England the autumn spread partook of the nature of a secondary type of epidemic, as compared with the primary type in the summer.

The second hypothesis is that the occurrence in the summer in England of an epidemic due to a virus imported from America or France or China, with its consequent increase in morbidity, so enhanced the virulence of a local endemic British virus that the latter produced the autumn epidemic. We see no necessity for complicating the question by the assumption of this second hypothesis.

6. Whether or not there is a regular periodicity of a definite number of weeks in the case of influenza, the fact remains beyond cavil that one of the dominant characteristics of epidemic influenza is its recurrence at intervals. The evidence is ample that the disease is distributed throughout many countries in inter-epidemic times and that intermittent outbreaks of large or small extent occur.

The most striking phenomenon is the fact that in March of 1918 influenza is reported as having been present in China, in the United States and in France. It is scarcely possible that the disease in its epidemic form could have been carried from any one of these three points to the other two in the remarkably short time between the onset of the three outbreaks. We are faced with the phenomenon of a simultaneous exaltation of the influenza virus in three remotely separated countries of the world. This one fact more than any other indicates that the fluctuation in virulence is dependent upon some factor intrinsic in the virus itself and not upon environmental factors.

It is impossible at the present time to decide whether the world epidemic spread simultaneously from these three foci or whether in only one of these three the virus became so exalted as to produce pandemic prevalence. All we can say is that we are able to trace consecutively the spread of the influenza from the focus in the United States throughout the world. The information upon which we base our findings is not statistical, and as we have previously said this latter type of demographic study should be brought into use to either corroborate or disprove our findings.

Virulence Enhancement.

Before attempting to study the mechanism of origin of the 1918 pandemic it is highly essential that we devote some attention to a consideration of the processes by which the germs of infection, particularly the virus of influenza, may develop an increase in virulence. Followers of the theory of periodicity would base virulence enhancement primarily on some intrinsic property of the virus itself. We know from past experience and particularly from animal experiments that this is not the only manner by which virulence may be increased.

As far as we know there is no new infectious disease. Individuals who delve into the history of the past inform us of more and more diseases which were well known to the ancients. We are frequently amazed at the variety of diseases now known to be infectious that were very correctly described by the Hippocratic writers. The infectious diseases are with us always and live nearly always in man, the host

There are few exceptions. Very few of the contagious viruses can live for any long period of time outside of the human body. A few, such as the plague bacillus, may live on other hosts, but these are the exception. The remarkable feature is that for long periods of time the virus exists in the host in a quiescent state and only at intervals does it become highly invasive and thereby produces epidemics of greater or less extent. Under what conditions does the metamorphosis of the microorganisms occur?

Topley, in the Goulstonian lectures, discusses this subject. He says: "The first difficulty with which we were faced in forming any theory of the spread of bacterial infection, which should conform to the known facts of epidemiology, was to find some explanation of the perpetuation of the virus during interepidemic periods. The bacteriologic data which have accumulated, especially during the last twenty years, have shown that the causative agents of specific diseases are to be found in apparently normal persons who give no history of having been in contact with the disease in question, as well as in contact with actual cases of the disease. Moreover, the organisms in question have been shown, in certain cases, to persist for long periods of time in or upon the tissues of their hosts, and we must always remember that the difficulty of bacteriologic technic is likely to lead to a serious under-estimate. Clinical and epidemiologic investigations have yielded confirmatory evidence, and we are thus left with a conception of the virus of a given disease being distributed fairly widely throughout the world as an apparently harmless parasite on the human host, but taking on during epidemic periods a new and sinister role, only to relapse again into comparative quiescence as the epidemic subsides."

He explains the rise of the epidemic wave as follows: "There are at least three possible explanations—an increase in the power of the parasite to produce disease, a decrease in the resistance of the host, and some attraction in the surrounding circumstances which favor the transference of parasites from case to case without any alteration of the pathogenicity of the one or in the resistance of the other. The third of these hypotheses may, I think, be disregarded. That alterations in environment may be the determining cause in initiating an outbreak of bacterial disease is probable enough; but they will almost certainly act through the variations which they bring about in the other two factors. The whole of bacteriologic knowledge is clearly against the occurrence of a considerable epidemic in which the pathogenicity of the parasite and the resistance of the host remain constant. Again, while we may well believe a lowered resistance of a certain

number of the host-species to be an important factor in the initiation of the process, yet we cannot believe that it is the whole story. The widespread ravages of many epidemics would seem altogether to preclude such an explanation. We seem forced therefore to the conclusion that an increase in the pathogenicity of the specific parasite is an essential factor in the rise of epidemics, excluding from this category small sporadic outbreaks which may be due to the introduction of a fully virulent parasite by a healthy carrier in some other way."

If a disease like measles is quiescent in a given community it must be that in that locality the hosts and parasites are existing in a state of biological equilibrium. They are living in a state somewhat akin to symbiosis. Such a condition could be attained either by a diminution of the invasive powers of the parasite, or by an increase in resistance of the host. Probably both elements are active; as the relative immunity of the host rises the infectivity or virulence of the parasite must rise to an equal extent to maintain the equilibrium. If this were true we would find that in those localities in which the disease is endemic and where the population is relatively resistant there is a normally more virulent virus in existence. A stranger coming into such a community would, in view of his lower resistance to the virus, be more susceptible of becoming actively infected. There would, however, be little danger of an epidemic spead because the number of susceptibles would, roughly, be limited to the number of strangers in the community. If, however, an individual from the community carrying the more virulent virus were to travel to another community where the greater proportion of the population was relatively less immune the field would be fertile for the beginning of an epidemic. Furthermore, there is the possibility of an outbreak in the first community if there should occur gross changes in its constitution; another infectious disease, a redistribution of the population with greater crowding, anything to change the balance between host and parasite.

Theobald Smith has described this possibility very clearly:

"During the elimination of the more virulent races of microorganisms, there goes on as well a gradual weeding out of the most susceptible hosts. In a state of nature in which medical science plays no part, there must occur a slight rise in the resistance of individuals, due to selection and perhaps acquired immunity, which meets the decline of virulence on the part of microbes until a certain norm or equilibrium between the two has been established. The equilibrium is different for every different species of microorganism, and is disturbed by any changes affecting the condition of the host or the means of transmission

of the parasite. One result of the operation of this law is the low mortality of endemic as compared with epidemic diseases. Certain animal diseases while confined to the enzootic territory, cause only occasional, sporadic disease, but as soon as they are carried beyond this territory epizootics of high mortality may result. Climate in some cases enters as an important factor, but the most important, perhaps, is the slight elevation in virulence brought about by a more highly resistant host. The most susceptible animals are weeded out and the rest strengthened by non-fatal attacks. The virulence of the microbe rises slightly to maintain the equilibrium. In passing into a hitherto unmolested territory, the disease rises to the level of an epizootic until an equilibrium has been established.

"The same is true of human diseases, among which smallpox is a conspicuous example. The great pandemics of influenza, which seem to travel from east to west every one or two decades, soon give away to sporadic cases, and the careful work of many bacteriologists would indicate that the influenza bacilli found at present have fallen to the level of secondary invaders, and are parasites of the respiratory tract in many affections."

Smith describes his hypothesis that the tendency of microbes in perfecting the parasitic habit is to act solely on the defensive. The aim of microorganisms, if we may speak of such, is to become able to live unharmed on the host. If they kill the host they have lost their home. The biologic tendency would be in this case for diseases which were once acute to become more and more chronic and indolent.

The extremely virulent parasite, which kills its host, will die with the host unless it has effected a means of exit before its death and escapes into a new host. For this reason Pasteur failed to exterminate the rabbits of Australia. He believed that with races of the bacillus of rabbit septicemia, which were very virulent, and which destroyed life very quickly, all that would be necessary was to start the disease among the rabbits of Australia and that it would tend to spread and would kill off all of the rabbits. But the parasite killed the animals before it had perfected for itself a means of escape from the body and thereupon died.

"From the biologic standpoint which I have endeavored to present, we may conceive of all highly pathogenic bacteria as incompletely adapted parasites, or parasites which have escaped from their customary environment into another in which they are struggling to adapt themselves, and to establish some equilibrium between themselves and their host. The less complete the adaptation, the more virulent

the disease produced. The final outcome is a harmless parasitism or some well-established disease of little or no fatality, unless other parasites complicate the invasion. The logical inference to be drawn from the theory of a slowly progressive parasitism would be that in the long run mortality from infectious diseases would be greatly reduced through the operation of natural causes. But morbidity would not be diminished, possibly greatly increased by the wider and wider diffusion of these parasites, or potential disease producers. The few still highly mortal plagues would eventually settle down to sporadic infections or else disappear wholly because of adverse conditions to which they cannot adapt themselves.

"In this mutual adaptation of microorganism to host, there is, however, nothing to hinder a rise in virulence in place of the gradual decline if proper conditions exist. In fact, it is not very difficult to furnish adequate explanations for the recrudescence and activities of many diseases today, though the natural tendencies are toward a decline in virulence. In the more or less rapid changes in our environment due to industrial and social movements the natural equilibrium between host and parasite established for a given climate, locality, and race or nationality is often seriously disturbed and epidemics of hitherto sporadic diseases result.

"These illustrations indicate that so-called natural law does not stand in the way of our having highly virulent types of disease, if we are ignorant enough to cultivate them. The microorganism is sufficiently plastic to shape itself for an upward as well as a downward movement. Among the most formidable of the obstacles toward a steady decline of mortality is the continual movement of individuals and masses from one part of the world to another, whereby the partly adapted parasites become planted as it were into new soil and the original equilibrium destroyed. These various races of disease germs become widely disseminated by so-called germ carriers, and epidemics here and there light up their unseen paths."

An example of increasing virulence from changing environmental conditions, is the experience in the United States Army camps in 1917 and 1918 with the streptococcus. This microorganism, which at first was but a secondary invader, particularly to measles, became so exalted in virulence that it soon became the cause of primary disease. This is likewise true of the various secondary invaders of the influenza epidemics. They become so highly virulent that they dominate the picture in the later stages. The organisms included in this group are particularly the streptococcus, the various pneumococci, and the

meningococcus. Probably the tubercle bacillus should be added to this list.

It requires a certain amount of time for such organisms to attain increased virulence. The earliest cases in any epidemic are comparatively very mild. Thus Major Billings, epidemiologist at Camp Custer, says that for the first five days of the autumn influenza epidemic in that camp the cases admitted to the hospital were very mild in character and were recorded as simple bronchitis and pharyngitis, of no great severity, the majority soon recovering. Five days after the first case was admitted, however, the entire symptom complex seemed to change, and the cases admitted to the hospital from then on were a very different and much more severe type. Major Billings, after going over the records, feels that both types of cases were the same disease, the second being a more severe form. Woolley reports essentially the same condition from Camp Devens.

The same phenomena were found in 1889. During the 1889 epidemic Prudden examined by current bacteriologic methods seven cases of influenza and six cases of influenza-pneumonia. In them he found staphylococcus pyogenes aureus, streptococcus pyogenes, diplococcus pneumoniae, and in other cases he found a streptococcus. He concludes that the use of culture methods and media commonly employed has brought to light no living germ which there is reason to believe has anything to do with causing the disease. He emphasizes the probable importance of streptococcus pyogenes in particular in inducing the various complications.

At this point we should include for the sake of completeness reference to a recent theory propounded by Sahli explaining influenza epidemics, a theory to which we do not subscribe. He believes that the pneumococcus, the streptococcus, the influenza bacillus, and possibly other organisms, form a complex group, an obligate complex, a symbiosis, a higher unit, which infects the organism as a unit. It is all of these organisms acting together which produce the influenza. After infection has occurred one or the other member of the group may develop preferentially. In favor of this he says that in one of his cases the sputum was swarming with influenza bacilli on one day, and that the next day the sputum was a thick pure culture of the pneumococcus. He says that if an ultramicroscopic germ should yet be discovered this would not invalidate the theory, but would merely add another member to the group forming the obligate complex virus unit.

Meteorologic conditions.—Formerly attempts were made to demonstrate etiologic relationships between the occurrence of influ-

enza and unusual conditions of the atmosphere. In most cases no relationship has been discovered. Nevertheless it is conceivable that the changes in the atmosphere, particularly seasonal variations, might influence the virulence of the organism. It has been found that nearly all of the many epidemics apparently originating in Russia took their origin there either in the late autumn or in the winter months. The spread of influenza appears to be uninfluenced by atmospheric conditions, but the severity of the disease is definitely increased in the winter months, and Leichtenstern believes that the development of a primary spread from its point of origin is also influenced by the season. Hirsch found that out of 175 correlated pandemics or epidemics, 50 occurred in the winter between December and February, 85 in the spring from March to May, 16 in the summer from June to August and 24 in the autumn.

The soil plays no part in the spread of the disease. It prevails on every soil or geologic formation; on the mountain top, in the low malarial swamps, in the tropics and within the arctic circle. Volcanic eruptions, fogs, electrical conditions, ozone, direction of the wind, have all been considered in previous epidemics and successively eliminated as etiologic factors.

It must be stated, however, that Teissier, who investigated the influenza in Russia in 1890 and has compared his conclusions at that time with the results of investigation of the recent visitation, believes that some particular cosmic conditions suddenly enhanced the virulence of an endemic etiologic microorganism—probably some ordinary germ—and that this opened the portals to secondary infections.

Secondary invaders.—We have considered a possible manner in which the virulence of the organism causing influenza may become enhanced. Whatever this organism may be, another and equally important virulence enhancement occurs in the opportunist group of the germs, so-called secondary invaders of influenza. As we have previously remarked, it is a characteristic of influenza outbreaks in all communities that the earliest cases are very mild. Secondary infection has not as yet obtained a foothold. After about a week the character of the illness changes, becoming distinctly more severe. Billings reported that at Camp Custer in the autumn of 1918 cases admitted to the hospital during the first five days were very mild in character and were reported as simply bronchitis or pharyngitis of no great severity, the majority soon recovering. After this time the entire symptom-complex seemed to change and the cases admitted to the hospital were of a very different and more severe type.

Benjafield reports that in the Egyptian Expeditionary Force the epidemic commenced in May, 1918, and that the cases occurring during the earlier portion of the epidemic were mild in type and of short duration, only a very small proportion being complicated by bronchopneumonia. Wooley found at Camp Devens that the first cases were of a mild form and were usually diagnosed "naso-pharyngitis, acute catarrhal." After a few days the disease became more severe and pneumonia cases developed.

Bezançon found that among the repatriated French soldiers from Switzerland those cases occurring in May and June had a much lower severity than in the later epidemic. Zinsser's description of the mild, earlier epidemic in Chaumont has already been quoted.

The secondary invaders of pathogenic importance are the various forms of the streptococcus and pneumococcus, the meningococcus, the staphylococcus, and probably the tubercle bacillus and the influenza bacillus. In the last epidemic as in that of thirty years previously, the chief complications were bronchitis and pneumonia. Capps and Moody found these to be the chief complications in December, 1915. Also they found a high incidence of sinusitis. This has been a feature of the last epidemic. Wooley cites a good example of the damage done by these opportunist organisms when they are present. Among the troops stationed at Camp Devens in the fall of 1918 pneumonia following influenza was particularly prevalent in a battalion of negroes from the South. This battalion had, a short time previously, passed through an epidemic of pneumonia and Wooley believes that many of the blacks were harboring the pneumococci which were only awaiting a favorable opportunity to invade their hosts. The influenza furnished the required opportunity.

That the meningococcus should be classed in this group is certain. The author observed at Camp Sevier cases of epidemic meningitis occurring in various influenza wards scattered throughout the hospital, with no demonstrable relationship. Usually there was but one case in a ward and almost invariably meningitis occurred when convalescence was beginning. No epidemic occurred in any ward. Others have reported actual epidemics of meningitis following influenza. Moss found that a large proportion of his influenza cases had the meningococcus in the circulating blood, as demonstrated by culture. Fletcher cultivated meningococci from the lungs in all of eleven autopsies, and in all eleven cases the influenza bacillus was also present.

In considering the effect of influenza on the death rate in general, and in considering the relationship of influenza to other diseases in

general, it is important to distinguish those diseases which are apparently unrelated and those diseases which occur as direct complications or sequelae. Bronchopneumonia, bronchitis, empyema, otitis media, frequently tonsillitis and sometimes erysipelas, occur as sequelae. Meningitis should frequently be included in this group.

Not only is there an increase in certain other diseases following influenza outbreaks, genetically related, as we have seen, but also some observers, particularly Crookshank, believe that previous to epidemic influenza prevalences there occurs an increase in the incidence of other entirely unrelated infectious diseases, such as poliomyelitis. This theory of simultaneous increase in invasiveness of many apparently unrelated germs is comparatively new and will probably receive deep consideration in the future. For the present the information on the subject is so limited that attempted conclusions would have no value.

Origin of the 1918 Pandemic.

In discussing the spread of the 1918 pandemic over the earth, the author has traced it from an apparent origin in the United States. Localized early epidemics are reported simultaneously in the United States, France, and China. From the literature at his disposal he has been unable to find convincing proof of an earlier origin in Asia, but he did emphasize at the time the necessity of a much more thorough study of influenza in all countries to be made by more competent statisticians. Nevertheless it is highly interesting to formulate an hypothesis which appears to meet all demands, on the assumption that the disease originated in America. In order to hold a theory with this basis we must assume that the third of our previously mentioned hypotheses of the origin of the disease is the more nearly correct.

Let us assume that in the interpandemic periods the influenza virus is widely distributed over the earth, existing in an avirulent form. The basis for this assumption is the previously described occurrence of localized epidemics in interpandemic periods. The occurrence of solitary cases, although of interest, could scarcely be considered as evidence of the widespread distribution of the virus, but in the case of the small outbreaks as in 1900, 1907 and 1915, and as in the numerous small outbreaks described by Hirsch, the character of the epidemic curve is characteristic. Let us, then, assume that the disease has been endemic in the United States, together with other localities. It requires no keen observation to discover in the years 1917 and 1918, Theobald Smith's "movement of individuals and masses from one

part of the world to another, whereby the partly adapted parasites become planted, as it were, into new soil, and the original equilibrium is disturbed." Not only was there a tremendous redistribution and concentration of individuals in our camps in this country, but also there was a further disturbance of the equilibrium in the outbreak of other infectious diseases, particularly measles. The effect of the measles epidemic on the virulence of the streptococcus and allied organisms has been discussed; presumably the same occurred with respect to the influenza virus. Howard and Love report that approximately 40,512 cases of influenza were reported in the United States Army during 1917. They write:

"In 1917, the death rate for the acute respiratory diseases (influenza, pneumonias and the common types) increased to 1.71. During the fall of 1917, after the camps were filled with drafted men, acute epidemic diseases swept through a number of them. Measles was one of the most prevalent and one of the most fatal of the infectious diseases that occurred. It was noted during the fall and early winter that there were a number of cases of pneumonia which were unlike the pneumonia that ordinarily occurred. This was apparent both to the physicians in civil life and in the army camps. It was reported by all classes of practitioners that numerous cases of pneumonia were occurring which resembled the pneumonia following measles, but occurring among men who had not had measles recently. In a number of the camps, both in the north and in the south, rather extensive epidemics of pneumonia occurred and a number of deaths resulted. The same variety of pneumonia occurred in the late winter and spring of 1918. In many of the camps pneumonia was practically epidemic during March and April. In many camps a number of cases occurred later in the spring and summer. It was again reported by a number of medical men that these cases of pneumonia that were occurring were different from the types of pneumonia ordinarily encountered and very similar to pneumonia following measles, but, again, that the cases occurred among men who had not had measles recently."

MacNeal has observed similar conditions in the American Expeditionary Forces in France in 1917:

"The American troops in France in 1917 began to show, as early as October, 1917, a very considerable rise in the influenza morbidity. The data available in the office of the Chief Surgeon, A. E. F., show an influenza morbidity per 100,000 of 321 in July, 438 in August, and 404 in September, rising to 1,050 in October, 1,980 in November, and 2,480 in December, 1917, in which month the total number of new

cases of influenza reported was 3,520. That a considerable proportion of these cases were actual infections with the bacillus of Pfeiffer is proven by the necropsy findings in fatal cases of bronchitis and bronchopneumonia, especially those performed by Major H. E. Robertson at Army Laboratory No. 1, Neufchateau, in November and December, 1917, and January, 1918. In these cases the bacillus of Pfeiffer was found in the scattered patches of lung involved in the bronchopneumonia and also with great frequency in the cranial sinuses. These necropsy findings were, at the time, recognized as essentially new for young adult Americans, and, in a discussion at Army Laboratory No. 1, during December, 1917, they were considered as being of possible important significance for the future morbidity of American soldiers in France. In the British Army in France there is definite evidence of epidemics showing the same pathologic condition, during the winter of 1916–17, and at Aldershot in September, 1917. There can be little, if any doubt that this disease was essentially the same which attacked the American soldiers late in 1917."

Schittenhelm and Schlecht have reported that a disease was studied among the German troops on the Eastern front which resembled greatly the influenza. It occurred from the beginning of August to the middle of October, 1917. It attacked simultaneously and in epidemic form units and divisions very widely separated over a large territory. It was characterized clinically by a very sudden onset, in the greater number of cases with chill, headache, pain in the extremities, sometimes thoracic pain and cough. The fever lasted seven to nine days. The spleen was enlarged in 11 per cent. of the individuals. There was diarrhea in 12 per cent., frequently conjunctivitis, and quite often a scarlatiniform rash. Bacteriologic examination of the blood was negative. There was usually leucopenia. No treatment seemed especially efficacious. Aspirin gave the best results. The authors call attention to the close similarity to influenza and also suggest that it might have been due to transmission by insects as in pappataci fever or in dengue.

Carnwath concluded that the finding of influenza bacilli in necropsies in British soldiers in 1917 was without epidemiologic significance in considering the origin of the 1918 pandemic. He had studied the disease among the British in detail and appeared to be of the opinion that the first influenza morbidity of significance among the British troops did not appear previous to April, 1918.

MacNeal further says: "The influenza rates per 100,000 of 1,050 in November and 2,480 in December, 1917, really indicate a greater

relative prevalence of influenza at that time in the A. E. F. than occurred in the fall of 1918, when the respective morbidity rates were 826 in September, 2,176 in October, and 1,356 in November. The total number of American troops in France was relatively small during that winter—141,995 effective mean strength in December—so that the prevalence of influenza did not lead to the recognition of an actual epidemic. Furthermore, the over-crowding in quarters, which seems to have had a definite relation to many of the later explosive outbreaks, had not become such a distinct feature at that time. In addition, the cold, wet weather, exposure and unusual living conditions furnished explanations for the morbidity which were no longer adequate during the hot weather of May and June, 1918. Until May, 1918, therefore, the prevalence was that of an endemic disease, with perhaps an occasional outbreak suggesting epidemic character."

We admit that MacNeal's report furnishes excellent evidence of an independent origin in France. Two points should be borne in mind. First, that MacNeal's figures are not for the French, but for the Americans who were transported to that country, and that we may consequently consider influenza among the American Expeditionary Forces as being possibly from the same source as influenza among the troops in our own country,—that the American Expeditionary Forces may be considered a subdivision of the American Army in the United States, equally well as a subdivision of the French population; second, that we have been unable to find detailed evidence of similar conditions occurring among the French troops or French population, where the conditions have been ripe in a way since 1914. MacNeal records that in March and April, 1918, there was a great increase in the number of troops brought over from the United States to France. Previous to that time there had been 287,000 in that country and during the two months 150,000 were added, with a consequent increase of more than fifty per cent.

We should insert a word of caution regarding the diagnosis of influenza among troops in the absence of any sign of an epidemic. Internists who served in base hospitals during the war will agree that a diagnosis of influenza is very frequently made on the admission card when the disease turns out to be some other malady. This was not equally true in all camps, but regimental surgeons could often be found who would transfer a patient to the hospital with the diagnosis of influenza used almost interchangeably with the diagnosis "Fever of unknown origin." It would be interesting to see statistics from one or two of those base hospitals which were manned with especially

competent internists, as to the frequency with which the admission diagnosis of influenza remained unchallenged in the hospital, during the year 1917.

There would be such cases in greater or smaller numbers. The magnitude of this number would not influence our hypothesis.

Aside from this discussion of the disease among our troops in France it is most important that we establish, if possible, the identity of the disease reported among British troops in Northern France during the winter of 1916–1917 and designated by the name "Purulent Bronchitis." The disease first appeared in December, 1916. It reached its height during February and early March of 1917, and appears to have disappeared early in the spring. Hammond, Rolland and Shore report that during February and early March 45 per cent. of the necropsies under observation showed the presence of purulent bronchitis, and they remarked that the disease assumed such proportions as to constitute almost a small epidemic. They described the clinical aspects as follows:

"The cases which came under our notice can be divided broadly into two types: The first and more acute presents a clinical picture which closely simulates ordinary lobar pneumonia with a sustained temperature of about 103°, and expectoration at first blood-streaked—rather than rusty— which, however, rapidly becomes quite purulent. The pulse-rate in these cases is out of all proportion to the temperature in its rapidity. Dyspnoea and cyanosis are prominent features. The patient usually dies from 'lung block,' resulting in embarrassment of the right side of the heart on the fifth or sixth day. For the last day or two there is often incontinence of the feces, due, no doubt, to the condition of partial asphyxia. The mental state is one of torpor; delirium is the exception.

"The second and less acute type is marked by a more swinging temperature with a range of two or three degrees. The expectoration at first may be frothy and mucopurulent, but it very soon assumes the typically purulent character. This form may run a long course of from three to six weeks, during which time the patient wastes a great deal and has frequent and profuse sweats; indeed, at a certain stage the illness is most suggestive of acute tubercular infection, and it is only by repeated examination of the expectoration that the clinician can satisfy himself he is not really over-looking a case of acute pulmonary tuberculosis. The majority of our cases conforming to this type have ultimately recovered, but the convalescence is slow and tedious.

"Onset.—Whilst a history of a previous catarrhal condition lasting for a few days is often obtained, the disease quickly assumes an acute character; we have been able to observe this in patients admitted into this hospital with purulent bronchitis; we find the temperature is between 102° and 103°, the pulse 120 or over, and the respiration about 35. The patient frequently complains of shivering and looks pathetically miserable, but we have not seen an actual rigor. Despite his obvious shortness of breath, the sisters have noticed that, at any rate at first, he prefers a lateral position low down in the bed, and resents any attempt to prop him up.

"Cough.—This for the first day or two may be irritable and distressing, with a little frothy expectoration, but as the latter becomes more purulent the cough is less troublesome, and soon the patient is expectorating easily and frequently, until the later stages are reached; when owing to increasing asphyxia the patient becomes more and more torpid, the cough subsides, and hardly any secretion is brought up. This failure becomes an added factor in bringing about a rapidly fatal termination.

"Expectoration.—The sputum, with its yellowish-green purulent masses, is very characteristic, and may be one of the first indications of the serious nature of the illness the patient is suffering from.

"Temperature.—The fever of this complaint does not follow any very constant type. In nearly all our cases the pyrexia was of sudden onset, and for the first few days was more or less sustained at about 103°. Later it conformed more to the swinging type with a range of several degrees. In a few cases a curious gradual ante mortem drop has been observed.

"Pulse.—Tachycardia is a very constant feature throughout the illness. The rate is frequently well over 120, though the volume may remain surprisingly good until immediately before death.

"Some degree of dyspnoea is always present, and is usually progressive, though towards the end in the fatal cases when the mental acuteness is dulled by the increasing asphyxia the patient is not distressed by its presence. In some cases there have been paroxysmal exacerbations of the breathlessness, accompanied by a state of panic, in which the patient struggles wildly and tries to get out of bed in order to gain relief. Cyanosis is another prominent feature throughout the illness. At first it may not be more than duskiness, but in the later stages it becomes very evident. It is only slightly relieved by oxygen; this, no doubt, is partly explained by the difficulty in giving the oxygen efficiently, owing to the patient's objection to any mouth-

piece that fits at all tightly, and partly by the blocked condition of the bronchioles interfering with the absorption of the oxygen.

"The condition usually begins with the presence of a moderate number of sharp crepitant râles, often first heard in the region of the root of the lung; these quickly become generalized. In the majority of the cases signs of bronchopneumonia patches can be made out; these are generally situated near the root of the lungs. In a certain number of cases these patches spread and become confluent, giving practically all of the physical signs of a lobar pneumonia. As the disease progresses the air entry is diminished; on listening one is often struck by the small volume of sound heard. The resonance of the lungs may also be lessened. A slight pleuritic rub was heard in a few of our cases, but this was soon masked by the bronchitis signs."

Detailed sputum examination in twenty cases showed the presence of the influenza bacillus in eighteen, and in ten out of these eighteen the organism was isolated by culture. The next most frequent organism found was the pneumococcus, which was present in thirteen cases. The streptococcus was found in five.

Abrahams, Hallows, Eyre and French report the same epidemic:

"A typical case is as follows. The onset is usually acute; the early symptoms are those of a 'cold in the head.' The temperature may be 101 or 102°, but there are no features to distinguish the condition from acute 'coryza' or febricula, so that in the majority of cases the patient does not report sick for two or three days, by which time he is sent to the hospital. At this state two features attract particular attention. First, the character of the expectoration: this consists of thick pale yellow, almost pure pus, not the frothy expectoration familiar in ordinary bronchitis; it has no particular odor and it becomes increasingly abundant until in a day or two it may amount to several ounces in the twenty-four hours. Secondly, the rapidity of the patient's breathing: this may be so evident that pneumonia suggests itself, yet on examining the chest the only physical signs consist of few or many rhonchi scattered widely, but most marked at the bases of the lungs behind, associated with a wheezy vesicular murmur; resonance everywhere is unimpaired and bronchial breathing is absent. A little later a third point attracts notice; a peculiar dusky heliotrope type of cyanosis of the face, lips, and ears, so characteristic as to hall-mark the nature of the patient's malady even on superficial inspection. By this time dyspnoea is very pronounced; respiration consists of short, shallow movements, which in bad cases amount almost to gasps, reminiscent of the effects of gas poisoning. Recovery

at this stage may occur, but by the time the cyanosis has become at all pronounced the prognosis is extremely bad, though the number of days the patient may still live, in spite of the severity of his distress, is often surprising. The character of the sputum remains the same throughout, though sometimes it is blood-tinged or actual blood may be expectorated instead of, or in addition to, the more typical pale yellow pus. In the later stages of the illness areas of impaired note or of actual dullness may be found, particularly over the posterior aspects of the lungs, associated with bronchial breathing and crepitant râles. These may be due to the progression of the purulent bronchitis into hypostatic pneumonia, or into actual bronchopneumonia at the bases; or, on the other hand, they may be due to massive collapse of the lungs secondary to the bronchitis and obstruction of the bronchioles by pus. In a few cases, not necessarily the most serious, a frank lobar pneumonia has developed later, and has been followed by an empyema from which 15–30 ounces of thin pneumococcal pus has been aspirated —in one case alone was resection of a rib unavoidable. The condition, however, is not primarily a lobar or a bronchopneumonia, but a bronchitis, and although a small amount of basal bronchopneumonia has been present in one or two of our post-mortem examinations, in other fatal cases there has been no bronchopneumonia at all, not even the smallest portions of either lung being found to sink in water.

"We have no doubt that the condition is primarily an affection of the bronchi and bronchioles, and not of the alveoli, though the alveoli may be affected later if the patient survives long enough. In a typical post-mortem examination it would be difficult, or almost impossible, to define the actual cause of death unless one knew the clinical history."

Abrahams and his collaborators describe in detail eight consecutive cases. A study of the type of onset may be of help in determining the character of the disease. The first patient had been subject to bronchitis for years. He had been ill with cough and some pyrexia for five days previous to his admission. There is no further description of his admission symptoms. Case two was admitted on March 17th, having taken ill the previous day with shivering, cold and pain in the chest. The temperature was 104°, the pulse rate 118, and the respirations were 44. The patient was very restless and had much dyspnoea but was not cyanosed. The third patient had taken ill three days previous to admission with symptoms of cold in the head and a sore throat. He complained of headache and dry cough without expectoration, shortness of breath, and a pain behind the sternum.

Case four was admitted with a history of having been out of sorts with a cold and bronchial cough for ten days previously. On admission his temperature was 103°, pulse-rate 112 and respiration-rate 36. He had abundant blood-stained purulent sputum.

Case five is the first case that shows a type of onset distinctly resembling that of influenza. The patient had been ill three days with headache, cough and generalized pain previous to his admission. The temperature on admission to the hospital was 103°, pulse-rate 112, respiration-rate 20. There were no abnormal physical signs in the chest on admission. They did appear two days later. Case six related that he had been sleeping under canvas for three nights before coming to the hospital, and that during the first of these nights he was taken ill with a cold which became associated with a cough and increasing shortness of breath. On admission there was slight cyanosis, and dyspnoea was very pronounced. Shortly afterwards he became orthopnoeic, with heliotrope cyanosis. On the slightest exertion, such as turning over in bed, the cyanosis increased markedly, and although the respiration-rate remained under forty when he was at rest, on the least exertion it increased to nearly sixty. The sputum was purulent and abundant, pale yellow, not frothy and not blood-stained, and the day after admission contained Bacillus influenzae, pneumococcus and Micrococcus catarrhalis.

Case seven had been ill seven days before admission with cough and fever. On admission his temperature was 105°, pulse 116, respiration 24. Case eight gave a history of having had a cough for eight days previous to admission. This cough had not incapacitated him much at first, but he became progressively worse during the four days before admission, with increasing shortness of breath and abundant yellow sputum which he found it difficult to raise. On admission dyspnoea with cyanosis was very evident.

Even from these detailed clinical descriptions it is impossible to say definitely whether the disease was or was not influenza. There is no doubt, however, but that clinically the disease resembled more the so-called streptococcus pneumonias that were observed in the United States camps in the winter of 1917–18. The descriptions of the mode of onset are particularly at variance with the onset as we know it in influenza.

Those who believe that the influenza bacillus is the cause of influenza maintain that the finding of this organism in a large per cent. of cases by both groups of observers is valuable evidence. For reasons previously stated we cannot agree.

Description of the epidemic features is not detailed enough to be of assistance. The first group of authors remark that the disease constituted "almost a small epidemic." The second group say that six out of eight cases in their series of carefully reported patients came from one command. The former report on twenty cases, the latter on eight. The latter remark that although they have dealt with only eight cases in detail, they had a much larger number altogether. Presumably there were a decidedly larger number of patients in both hospitals, but the actual number is not stated. In short, we do not know whether the disease appeared to be more or less epidemic than the apparently similar disease among our troops in the winter of 1917–18.

Both groups of observers have described in some detail the pathology of the cases which were necropsied. The author in attempting to obtain further comparative information has submitted the pathologic descriptions given by the British authors to Dr. E. W. Goodpasture, who has very kindly pointed out the points of similarity and difference between the gross and microscopic findings in these cases of purulent bronchitis, and the same findings in typical influenza. He says that the lung picture, as described, is not the same as that which was typical of the acute influenza observed in the autumn of 1918 and again in the winter of 1920. The characteristic picture in the latter is primarily an extensive involvement of the alveolar structure, while as Abrahams and his associates remarked, the condition in their case is primarily "an affection of the bronchi and bronchioles, and not of the alveoli, though the alveoli may be affected later, if the patient survives long enough." Goodpasture states that the pathology as described by the British authors is very similar to the lung picture in interstitial bronchopneumonia described by MacCallum for the post-measles and primary bronchopneumonia among our troops in the winter of 1917–18. The streptococcus and the influenza bacillus were dominant organisms in MacCallum's series. It also resembles the pathologic picture described by Pfeiffer in his original article on one of the late recurrences of the 1889–93 epidemics of influeuza.

In summing up, we must admit that it is impossible to reach a definite conclusion, but that both clinically and pathologically the disease described among the British troops in 1916 and 1917 was not typical of influenza as we have known it more recently. The similar conclusion reached by Carnwath, presumably chiefly from epidemiologic considerations, has already been described. We do not deny that this "purulent bronchitis" *may* have been influenza. On the

contrary, it is a part of our hypothesis that influenza under the proper conditions may become epidemic in practically any land. But we do believe that the evidence has not shown that the disease among the British troops in 1916 and 1917 was an etiologic precursor of the great pandemic.

To return to a discussion of influenza in China, we quote from an article by Cadbury in the China Medical Journal: "Unfortunately no health reports are available for the greater part of the Chinese Republic. We have consulted, however, the Health Reports of the Shanghai Municipal Council from 1898 to 1917, and among the total foreign deaths we find that only the following were attributed to influenza: 1899, one death; 1900, one death; 1907, four deaths; 1910, one death. After this no deaths are recorded from this cause up to and including the year 1917.

"In the Hongkong Medical and Sanitary Reports, which give the total deaths registered in the Colony, we have examined the records from 1909 to 1917. During these nine years only two deaths were attributed to influenza, and both occurred in 1909.

"From a personal letter from Dr. Arthur Stanley, Health Officer in Shanghai, dated February 11, 1919, I quote the following:

" 'As to influenza we had an attack beginning at the end of May and lasting through June and again in the latter part of October and lasting through November. The latter was somewhat more severe. The noteworthy features were general absence of catarrhal symptoms, congestive pharynx frequent, as also was a slight erythematous blush on the neck and chest, which made one think at first of scarlet fever. Fatal pneumonia common among the Chinese and Japanese, but among Europeans very little pneumonia.'

"In his report for May, 1918, Dr. Stanley says that the disease was reported to have reached Peking before it came to Shanghai, but subsequent reports showed that most of the river ports were almost simultaneously infected, the rate of spread conforming to the rate of conveyance by railways and boats of infected persons. The mortality was very low.

"Newspaper reports indicate that a third appearance of the disease in Shanghai occurred from the middle of February, 1919, which was still prevalent in April. The symptoms were much more severe.

"For Hongkong I quote from a personal letter from Dr. Hickling, the Principal Medical Officer of Health, dated January 29, 1919:

" 'The epidemic of influenza in the spring was a very mild one, so far as we can judge. The disease did not last more than a few days in

most cases. The recent epidemic (October, November, December and January) has been much more severe, often lasting two or three weeks.'

"Only one death, which occurred on May 14th, was reported from Hongkong in the spring. In the later epidemic the deaths reported were as follows: October, 70; November, 95; December, 67. The first of these deaths occurred on October 5th. The figures for January had not been compiled, but the disease was diminishing.

"Dr. C. W. McKenny of Hongkong has kindly furnished me with the following facts: '' 'During the first five months of 1918 there were twenty-two admissions for influenza to the Civil and Tung Wa hospitals (3 in May). In June there were 269 cases with three deaths. In July, August and September, 43 cases; and during October-November, 130 cases with four deaths. . .

" 'The June epidemic in Canton appeared first at the Pui Ying School, then among the employees of the Post Office, the staff of the Canton Hospital, the Canton Christian College, and the Kung Yee Hospital. The other schools entirely escaped. Eleven days were taken by the disease to spread from one part of the city to the various other parts.' "

Plague appeared in the north of China in 1917, originating apparently in inner Mongolia. The spread extended over quite an area, and it is reported that this epidemic of pneumonic plague has been more extensive than any since that of 1910–11. The disease was first reported prevalent in Patsebolong December 6, 1917. The diagnosis was confirmed bacteriologically, and there can be little doubt but that the cases of plague reported in various parts of China even up to March 18th were true plague, and not unrecognized influenza.

SECTION III.

In the following section of our report we shall have frequent occasion to refer to a series of investigations conducted by the author in the City of Boston during the 1920 influenza epidemic. We will explain in some detail at this point the nature of the work done and the methods used, in order that the subsequent references will be readily intelligible.

An Investigation of Influenza in Boston During the Winter of 1920.

Following every widespread epidemic interest centers in the question as to how much havoc the disease has wrought, what proportion

of the population fell victim, and how many of these died. With regard to influenza the vital statistics of all countries are decidedly insufficient in furnishing this information.

In nearly all countries influenza is not a reportable disease. Usually, as was the case in the United States in 1918, the disease was made reportable during the epidemic, but this took effect usually at least two weeks after the epidemic had started in a community. Further, there is probably not a single community in which the reported cases of influenza reach to anywhere near the total of actual cases. The question of diagnosis, which is not always easy even in the presence of a pandemic, causes some physicians to hesitate to report cases. Other physicians "play safe" and report nearly everything as influenza. Finally, in the period of an epidemic, the physicians are so pressed with caring for the sick that they very naturally neglect to report cases as they occur.

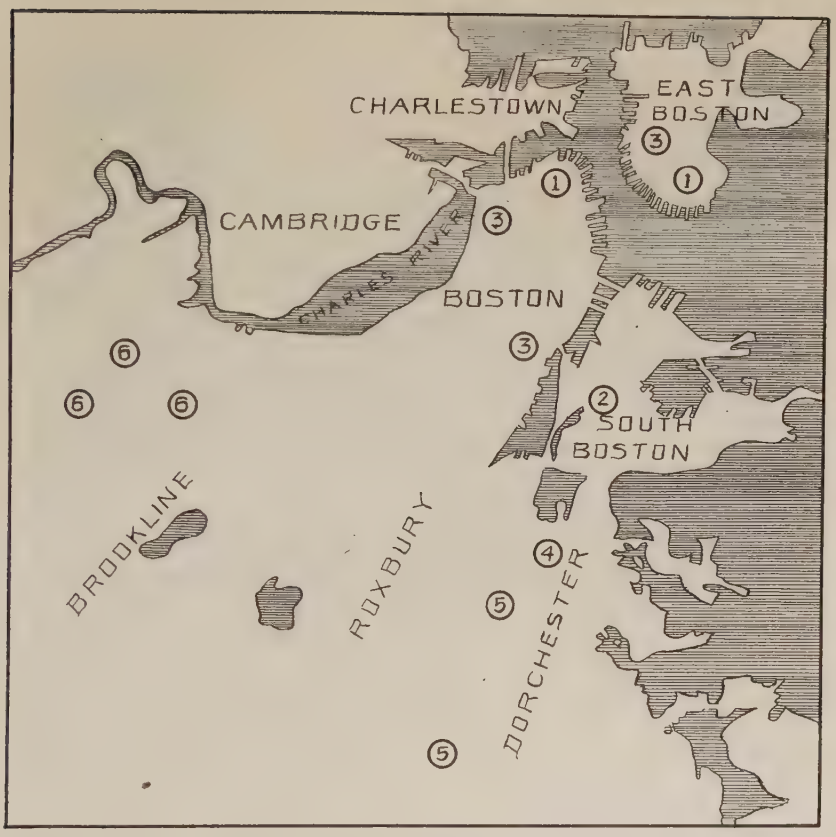
It becomes necessary, therefore, in collecting evidence in civil populations, of the morbidity and fatality from influenza, to obtain additional information to that available to the Health Officer.

The method which may be relied upon to give the most accurate data consists in house-to-house surveys made soon after an epidemic, in which competent inspectors obtain detailed information concerning the illness or freedom from illness of every individual in the areas canvassed. The majority of individuals interviewed will not have had the disease, and it is therefore essential that in such a census a large enough population be covered that the resulting figures will be truly representative of the population at large.

Toward the end of January, 1920, when the recurrent epidemic was at its height in Boston, the author undertook with the aid of thirteen trained social service workers, and one physician, who was a graduate of the Harvard School of Public Health, to make a sickness census of 10,000 individuals. Six districts were chosen in different sections of the city, representing six different economic and social groups. Great care was exercised in selecting the districts, so that the population in each might be as homogeneous as possible regarding economic and sanitary status, as well as race, and living conditions in general.

We have sought to clarify and to abbreviate our description of the characteristics of the various districts by incorporating a map, together with photographs of typical streets in each district. One who compares these streets as they are seen in the photographs would scarcely find it necessary to enter the buildings in order to discover the living conditions of the occupants (Chart XIII).

CHART XIII.



Map of greater Boston showing the distribution of the districts covered by the author's house census.

District I includes an Italian population of 2,000 individuals, one-half of which live in the most congested portion of the city (see photograph) known as the North End, while the other half, living in East Boston, are slightly less crowded.

District II, in South Boston, consists of 2,000 individuals almost entirely of Irish race stock.

FIG. 1.—District 1. Italian tenements. Very congested and very poor.

District III, like District I, consists of three groups living in very similar environment to the two groups of the first district, but composed chiefly of Jewish race stock of various nationalities. The photograph for this district represents the area in the "West Side" near the Charles River Basin. The area in the "South End" is of similar type, while the area in East Boston is housed similarly to the Italian district in East Boston. The dwellings in both of these latter districts correspond to those shown in the second photograph of District II.

While the first three districts comprise tenement areas, some poor and the remainder very poor, Districts IV and V represent the middle class, and consist nearly entirely of "Duplex" and "Three-Decker" buildings. The first of these comprises 1,000 individuals of mixed race and nationality, the type broadly spoken of as American. The second consists of a Jewish population of 1,600.

FIG. 2.—District 2. Irish tenements. Congested and poor.

FIG. 3.—Another street in the Irish tenement district.

FIG. 4.—District 3. Jewish tenements. Very congested. Very poor.

FIG. 5.—District 4. Middle class. Mixed American population.

FIG. 6.—District 5. Middle class. Jewish population. Moderately well-to-do.

FIG. 7.—District 6. Well-to-do population. Mixed American.

In District VI are included 1,400 individuals belonging to the well-to-do and moderately wealthy families of Brookline.

The six districts may be considered as representative of the various strata of society, so that we are enabled to study the influenza and its mode of action under varying environment. We have selected areas in the city consisting of households or homes rather than boarding houses and rooming populations. After a few attempts in the latter group we became convinced that the information obtained in rooming houses was utterly valueless. In the Jewish districts we were able, through the kind co-operation of the Federated Jewish Charities, to use trained Jewish Social Service Workers, each of whom had previously worked in the district assigned to her, thereby possessing the confidence of the inhabitants. They were also able to speak the language. One-half of the Italian district was surveyed by an Italian physician and the other half by an American Social Service Worker who knew the Italian language.

The information obtained was recorded on printed forms, which were filled out in accordance with detailed written instructions. Form "A" contained the necessary information concerning the family as a whole, including statistical data of each individual, description of the dwelling, of the sanitary condition, of the economic status, etc. Form "B" was filled out for each individual and gave detailed information as to the occupation and illnesses during the 1918–19 or the 1920 influenza epidemics, or during the interval. Form "B" was so arranged that the inspector was not called upon to make the diagnosis of influenza, but to record the various symptoms as described by the patient. The decision as to the diagnosis was made later, by the author. All blank spaces were filled in with either a positive or negative answer, so that the reviewer knew that all questions had been asked and answered. (See Appendix.)

The inspection was begun on February 9th, at the height of the epidemic. All records were turned in and reviewed by the author, who blue-penciled obvious inaccuracies and incorporated directions and questions in those instances where he desired further information. The records were then returned to the inspectors who, at the termination of the epidemic early in March, surveyed the entire 10,000 a second time, checking up their first record, correcting any inaccuracies, and adding records of additional cases of influenza which had occurred in the interval.

The most careful statistical surveys and compilations are not without error. We have gone into considerable detail in the preceding

description in order to demonstrate the several checks that have been made upon the work, without which information others would be unable to judge of the accuracy or value of our work.

Diagnostic standards for the 1918 *epidemic.*—All cases of illness recorded on the reports, which have occurred during either the 1918 or the 1920 epidemics, or in the interval between them, have been put into four groups as regards diagnosis of influenza. Cases are designated as "Yes," "Probable," "Doubtful," and "No."

Cases of illness occurring during the months of 1918 and 1919 in which influenza was epidemic and in which the patient remembers that he had the more definite symptoms, (fever, headache, backache, pain in the extremities, pneumonia) and in which he was sick at least three days and in bed at least one day, have been designated as "Yes." The symptoms chosen are those most likely to be remembered. The individual frequently does not remember all. Statements of the absence of fever are often unreliable. Usually the headache, backache or pain in the extremities, or even all of these are well recollected.

Cases occurring particularly during the epidemic period in which the more definite symptoms are unknown, but who were sick three days or longer and who were in bed at least one day, were probably influenza. This is particularly true if there were no other symptoms suggestive of some other definite disease. Such cases were designated "Probable."

Cases have been designated as doubtful when the evidence of illness falls short of the above desiderata. Cases of true influenza may fall into this group, either because of the extreme mildness of the symptoms and course or because of the inaccurate memory of the individual concerning the events of his illness sixteen months previously. Our results show that the group of doubtful cases is relatively very small and the number of true cases lost in this group will be negligible.

One important reason for adhering to the above classification is that it corresponds closely with that used by Frost and Sydenstricker, so that our results may easily be compared with theirs.

Standards for 1920.—For 1920 the illnesses were so recent in the minds of the patients that we have required rather full information for making the diagnosis of "Yes." For this designation certain symptoms are arbitrarily required. Certain additional symptoms, if present, serve to strengthen the diagnosis of influenza. The required symptoms are fever, confinement to bed for one day or more and at least two out of the following three, headache, backache and pain

in the extremities. The additional symptoms which influence the classification are sudden onset, prostration, lachrymation, epistaxis, and cough.

Cases designated as probable are those in which the symptoms as enumerated above are incomplete in one or more details, but yet in which the diagnosis of influenza would be justified. "Probable," therefore, means that the case is to be accepted among the list of true influenza cases. This is particularly so when the case occurs during the epidemic period.

"Doubtful" applies to those cases in which the evidence although suggestive of influenza, is not complete enough to warrant such a diagnosis. The doubtful feature may be in the lack of too great a number of the symptoms enumerated, or the presence of symptoms which might be due to some other disease. Certain cases occurring at the same time with other cases of typical influenza in the same household, and which would otherwise have been recorded as doubtful, have been marked either "Probable" or "Yes."

Standards of severity.—A purely arbitrary classification of severity has been adopted. Probably no two observers would agree exactly on a classification of this nature, but for the purposes of this study the following will suit all requirements provided the standard used is carried in mind throughout the comparison.

If a patient with influenza is under medical care, and the case is one of ordinary severity, the usual period in which the individual is advised to remain in bed is one week. This is the basis of the criteria of severity.

Mild.—A case is recorded as mild if the individual has remained in bed three days or less; *Average*, if in bed four to seven days; *Severe*, if in bed over seven days. *Pneumonia.* This designation is added to that of "severe" only in case the physician made such a diagnosis, or if the evidence under "symptomatology" leaves no doubt as to the condition.

Examples of individual exceptions to the preceding general classification are as follows: An individual in bed two days, but sick for three weeks might be recorded as average. A mother, with a family of sick children and who spent no time in bed may have been a severe case of influenza. In fact, we have allowed ourselves a certain latitude in individual cases in classifying both the diagnosis and the severity of the disease.

In the final tabulation we have included both the "Yes" and the "Probable" as being cases of influenza. This has been done after a careful comparison of both groups.

As a check upon the reliability of the work we have compared our results for the 1918 epidemic with those reported by Frost and Sydenstricker and have discovered that with regard to the general subject discussed in both studies there is close agreement. This is important in view of the long period that has elapsed between the first pandemic and the time of our survey, and because we are unable to compare our tables of incidence for 1918 with those for the city or the state at large. Our own records do not place the date of occurrence of the disease in 1918 any more closely than by month.

We have compared our 1920 incidence curves with those of Massachusetts and find a close correspondence, particularly in the date of onset, peak, and disappearance of the epidemic. We have done likewise for the occurrence of the disease in the city of Boston at large (Chart XIV).

In the past but few house-to-house canvasses have been made with relation to influenza. Auerbach, following the 1889 epidemic, collected statistics on 200 families distributed throughout the city of Cologne. Abbott, while not conducting a canvass, did obtain a certain amount of valuable information by letters addressed to physicians, institutions and corporations throughout the State of Massachusetts.

There is fairly abundant literature on the disease as it occurred in institutions. Moody and Capps, in a study of the epidemic in Chicago in December, 1915 and January, 1916, made a survey of the personnel and inmates of four institutions in that city. Among other rather numerous statistical compilations from institutions we may mention that of Hamilton and Leonard which was devoted particularly to a study of immunity, and that of Stanley at San Quentin Prison, California.

Garvie has reported his personal experience with influenza in an industrial area and discusses the disease as it has occurred in families in his private practice.

Carnwath reports a "block census" undertaken by Dr. Niven in Manchester, England. This is of the same nature as our own work. Reeks has made a detailed house survey of 2,757 persons in New Britain, Connecticut. D. W. Baker has conducted somewhat similar surveys for the New York Department of Health, and Winslow and Rogers quote the excellent record of the Visiting Nurse Association of New Haven, in which they have information for all of the families cared for by the nurses. This, however, is a collected group and does not correspond with the so-called block census.

CHART XIV.

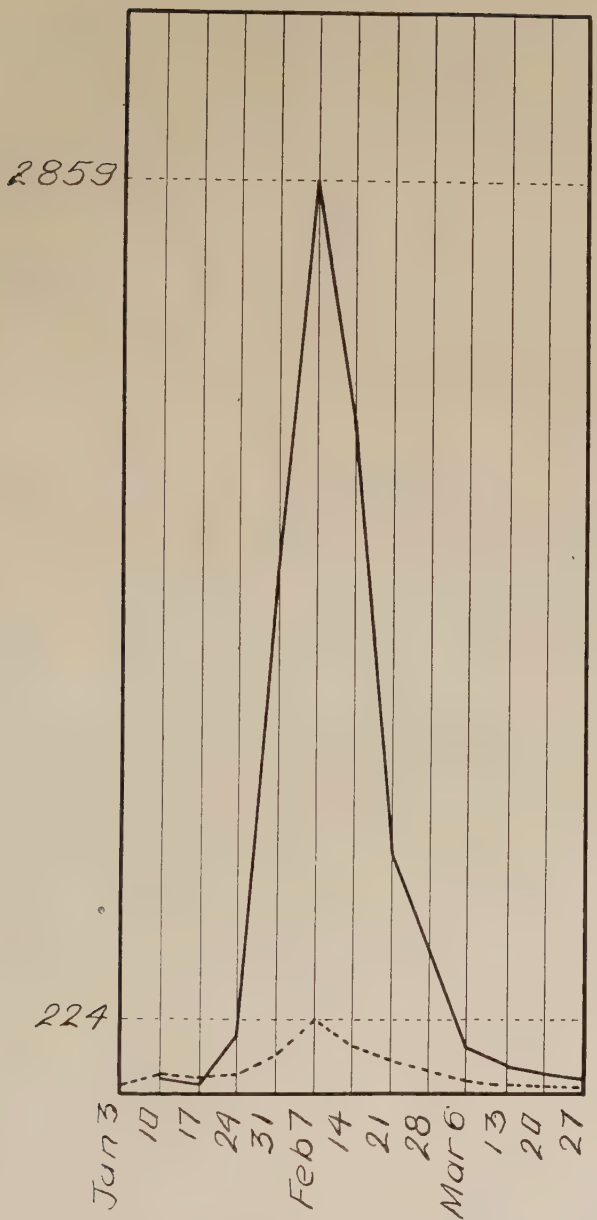


Chart showing the actual incidence of influenza in Boston by weeks and the actual incidence among the 10,000 individuals surveyed by weeks during the first three months of 1920.

Full Line—incidence in the entire city based upon reports to the Health Commissioner.

Dotted Line—incidence in the six districts surveyed.

The most comprehensive and detailed work that has been done in this line is that reported by Frost and Sydenstricker and by Frost, the first being the result of a canvass of 46,535 persons in Maryland, and the second a similar report based on a canvass of 130,033 persons in several different cities of the United States. We shall have occasion to refer to these later.

Morbidity.

There has been great actual variation in the morbidity from influenza in the various epidemics and even in different localities during single epidemics. Previous to 1889 there were no reliable statistics for the disease incidence, and subsequent to that date the records, for the reasons previously mentioned, have still been not entirely adequate.

In the history of influenza morbidity, as in that of its mortality, we must content ourselves for information prior to the nineteenth century with the very general estimates made by contemporary historians. During the last century the statistics have been more numerous and more nearly correct. As far back as the first recognized pandemic, 1510, the extremely high morbidity has been a recognized characteristic. Thomas Short in speaking of this pandemic says, "The disease . . . . . attacked at once and raged all over Europe, not missing a family and scarce a person."

Pasquier in 1557 spoke of the disease as common to all individuals, and Valleriola describes the widespread distribution of the epidemic throughout the whole of France during that year. It spared neither sex, age, nor rank, neither children nor aged, rich nor poor. The mortality, however, was low, "children only, dying." Again, Thomas Short remarks, "This disease seized most countries very suddenly when it entered, catching thousands the same moment."

Of the second pandemic, 1580, Short says, "Though all had it, few died in these countries except such as were let blood of, or had unsound viscera."

Thomas Sydenham remarks that in the epidemic of 1675 no one escaped, whatever might be his age or temperament, and the disease ran throughout whole families at once.

Molineux recorded concerning 1693, "All conditions of persons were attacked, those residing in the country as well as those in the city; those who lived in the fresh air and those who kept to their rooms; those who were very strong and hardy were taken in the same manner as the weak and spoiled; men, women and children, persons of all ranks and stations in life, the youngest as well as the oldest."

Schrock tells us that in Augsburg in 1712 not a house was spared by the disease. According to Waldschmidt in Kiel, ten and more persons were frequently taken ill in one house, and Slevogt says that the disease was fearful because so many persons contracted it at the same time. The disease was, however, not dangerous, for Slevogt continues: "Fear soon vanished when it was seen that although it had spread all over the city, it left the sick with equal rapidity."

It is estimated that in the epidemic of 1729–1730, 60,000 people developed the disease in Rome, 50,000 in Mayence, and 14,000 in Turin. In London "barely one per cent. escaped." In Lausanne one-half of the population, then estimated at 4,000, was stricken. In Vienna over 60,000 persons were affected. In the monasteries of Paris so many of the inmates were suffering from the disease that no services could be held.

Huxham is quoted in Thomson's "Annals" as declaring concerning the epidemic of 1732–33: "Not a house was free from it, the beggar's hut and the nobleman's palace were alike subject to its attack, scarce a person escaping either in town or country; old and young, strong and infirm, shared the same fate."

Finkler writes as follows concerning the epidemic of 1758: "On Oct. 24th, Whytt continues, the pestilence began to abate. He is not sure whether this was due to a change in the weather, or because the disease had already attacked most people, although the latter seems more plausible to him, particularly as he says that 'in Edinburgh and its vicinity not one out of six or seven escaped,' and in other localities it is said to have been even worse. In the north of Scotland also, the epidemic was greatly disseminated from the middle of October to the end of November. A young physician wrote to Robert Whytt: 'It was the most universal epidemic I ever saw, and I am persuaded that more people were seized with it than escaped.' This same physician reported that 'it was not at all mortal here.'"

In the epidemic of 1762, we learn from Razoux, de Brest, Saillant, Ehrmann, that the morbidity was great while the mortality was low.

According to Grimm, nine-tenths of the inhabitants of Eisenach contracted the disease in 1767.

Daniel Rainy, of Dublin, in describing the invasion of an institution in 1775–76, tells us that from among 367 persons varying in age from 12 to 90 years, 200 were taken sick. Thomas Glass says: "There sickened in Exeter Hospital all the inmates, one hundred and seventy-three in number; one hundred and sixty-two had coughs. Two or three days after the hospital was invaded the city workhouse

was attacked; of the two hundred paupers housed there only very few escaped the disease."

Gilibert described an extraordinary morbidity in Russia in 1780–81.

Metzger says that in 1782 the Russian catarrh was so universal during the month of March that in many houses all the inhabitants were attacked. During this period, "in St. Petersburg, 30,000, and in Königsberg, 1,000 persons fell ill each day;" in Rome two-thirds of the inhabitants were attacked; in Munich, three-fourths; and in Vienna the severity of the epidemic compelled the authorities to close the theaters for eight days.

The epidemics of 1788–89, 1799–1800 and of 1802–1803 were characterized by a relatively lower morbidity than that of 1830–32, in which the morbidity was again enormous. Likewise in 1833, the morbidity was very great. In Prague "scarcely a house was spared by the plague." In Petrograd, 10,000 persons were attacked; in Berlin at least 50,000. These are the figures of Hufeland. The Gazette Médicale records the morbidity as being four-fifths of the total number of inhabitants of Paris.

In 1836, according to Gluge, 40,000 persons suffered from the disease in Berlin alone.

In London, in the 1847 epidemic, it has been calculated that at least 250,000 individuals took sick, and in Paris, according to Marc d'Espine, between one-fourth and one-half of the population developed the disease, and in Geneva not less than one-third.

Leichtenstern informs us that in 1890 the early reports were made by clinical men and were mere presumptions. They were almost universally higher than the later statistical findings. The early estimates for the morbidity in several German cities were from 40–50 per cent. On the other hand, one of the highest statistical reports recorded by Leichtenstern was for Strasbourg in which 36.5 per cent. of the individuals became sick. The average morbidity reported by him ran between 20 and 30 per cent. The difference is accounted for in part by the fact that some of the very mild cases were not recorded in the statistics, and in part by the tendency in giving estimates, to exaggerate.

Auerbach has collected the statistics of 200 families distributed throughout the city of Cologne. He found that 149 of these families (75 per cent.) were attacked. In these, 235 were ill—59 men, 95 women, and 81 children. The larger number of women was explained as due to the illness of the female servants. He estimates each family as consisting on an average of six individuals, and concludes that 20 per cent. were taken with the disease.

Following the 1889 epidemic, Abbott concluded, on a basis of questionnaries sent out to various individuals and institutions in the State of Massachusetts, that 39 per cent. of the entire population had been attacked, in all about 850,000 persons.

Moody and Capps, in December, 1915, and January, 1916, made a survey of the personnel and inmates of four institutions in Chicago, the Michael Reese Hospital, the Illinois Training School for Nurses, the Old Men's Home, and St. Luke's Hospital Nurses Training School, making a total of 677 persons surveyed, of whom 144 developed influenza, making a percentage morbidity of 21. They remarked that there were many others with colds who remained on duty and were not included in the table and were not diagnosed as influenza.

We have already described the relatively low morbidity and mortality in the early spring epidemic in the United States. According to Soper, the total number affected in March, 1918, at Camp Forrest and the Reserve Officers Training Camp in the Oglethorpe Camps was estimated at 2,900. The total strength at that time was 28,586. The percentage morbidity then was probably a little over 10 per cent. Dunlop, in describing the May, 1918, epidemic in Glasgow, says that it was more limited in extent, as well as milder, than the later epidemic.

It has been estimated that in the autumn epidemic in the United States Army Camps one out of every four men had influenza, and one out of every twenty-four men encamped in this country had pneumonia. During the four autumn months of 1918, 338,343 cases of influenza were reported to the Surgeon General's Office; there were 61,691 cases of pneumonia.

Woolley reports that among the soldiers at Camp Devens, Mass. 30 per cent. of the population was affected.

At Camp Humphreys, 16 per cent. of the entire personnel developed the disease. The camp had an average strength of 26,600 individuals. Fifty-two per cent. of the entire number of cases occurred during the peak week, which ended October 4th. The outbreak began September 13th and ended October 18th.

Hirsch and McKinney report that an epidemic of unusual virulence swept with great rapidity through several organizations in Camp Grant between September 21, 1918, and October 18, 1918. During this time 9,037 patients were admitted to the Base Hospital, representing about one-fourth of the strength of the camp, and of these, 26 per cent. developed pneumonia. About 11 per cent. of the total admissions or 43 per cent. of the total cases of pneumonia died.

Referring to the report of Howard and Love, we quote as follows: "It is probable that practically all susceptible human material in infected camps suffered from an attack of the disease during the continuance of the epidemic. The records from various camps indicate that from 15 to 40 per cent. of commands suffered from an attack of the disease. These records, as previously stated, do not indicate in full the true incidence of the disease. Certain good results were accomplished in some camps by the application of effective and early isolation of patients and suspects and other measures generally recognized as of value. It was sometimes possible to retard the progress of the epidemic and cause it to be spread over a longer period of time. The epidemic thus became less explosive in character, and fewer people were under treatment at the same time. It was possible to take better care of the sick and thus reduce the incidence of and deaths from complicating pneumonia. It has not been shown that such measures accomplished reduction in the absolute number of cases of influenza occurring in one command as compared with another.

"The 'cantonment' group of camps gave a much higher death rate from influenza and its complications than the 'tent' camp or 'departmental' group. At first glance it would appear that the different housing conditions and the more marked overcrowding in cantonments at the time would fully account for this divergence. Closer study, however, leads to the conclusion that geographical location was a factor of equal or greater importance. It is well known that the disease was most virulent and fatal in the northern, eastern and middle west states, a district in which cantonments predominated. In the southern and Pacific coast states, where the most of the tent camps were located, a milder type of the disease prevailed, with fewer resultant fatalities. Camp Lewis, Washington, and Camp Gordon, Georgia (both cantonments), had relatively low death rates, approximating those in nearby tent camps. On the other hand, Camp Syracuse, New York, and Camp Colt, Pennsylvania (both tent camps), suffered severely and reported death rates approximating those of cantonments in the same geographical district."

Three waves of influenza are reported by Stanley at San Quentin Prison. During the early wave it was estimated that over 500 of the 1,900 men in the prison population were ill. The wave lasted for a little over two weeks. In the second epidemic there were 69 cases in all, ten per cent. of which developed pneumonia, with two deaths. There were fewer ambulatory cases than in the first. Three and seven-tenths per cent. of the population was attacked in the second

epidemic, as compared with 27 per cent. in the first. In the third epidemic there were 59 cases, with no pneumonia and no deaths.

Hernando estimates that in the Philippine Islands, 40 per cent. of the total population of 7,000,000 was stricken with the disease. The epidemic began in June, although it did not become severe until October. The group of ages that suffered most were those between ten and twenty-nine years. Hernando does not believe that the disease was imported because cases were reported before ships arrived from infected countries. After the importation of cases from elsewhere the disease assumed the more severe form.

Armstrong, in reporting a survey of 700 influenza convalescents in Framingham, Mass., remarked that 16 per cent. of the entire population were infected with influenza. Reeks, in a house survey in New Britain, Connecticut, found from among 2,757 persons that the morbidity rate reached 234 per thousand. Dr. Niven found in his block census in Manchester, England, that of 4,721 individuals, 1,108 (25 per cent.) had developed the disease. Fourteen and eight-tenths per cent. of the population were attacked in the summer and 10.4 per cent. during the autumn and winter.

Frost found in his survey of 130,033 individuals that the percentage of the population attacked varied from 15 per cent. in Louisville, Ky., to 53.3 per cent. in San Antonio, Texas, the aggregate for the whole group being about 28 per cent. He remarks that this agrees with scattered observations in the first phase of the 1889–1890 epidemic, when the attack rate seems to have varied within these limits. In five of the localities studied, geographically widely separated, the incidence rate varied only within a narrow limit, from 200 to 250 per thousand. Variations in attack rate showed no apparent consistent relation to geographic location or size of community, or to the rapidity of development of the epidemic.

In a house-to-house survey of 10,000 individuals in Boston the author found that in the winter of 1918–19, 19.71 per cent., or one-fifth of the entire population had developed the disease. It should be pointed out that while the standards used in this survey are entirely comparable to those used by Frost, the author has, contrary to Frost's method, not included in his group of positive cases those classified as "doubtful." This would raise the total incidence to a certain extent, but we feel convinced that by omitting the doubtful cases we have approached nearer to a correct picture of the epidemic as it actually occurred. As will be seen from Chart XVI there was no great variation in the different districts studied, with the exception of Dis-

CHART XV.

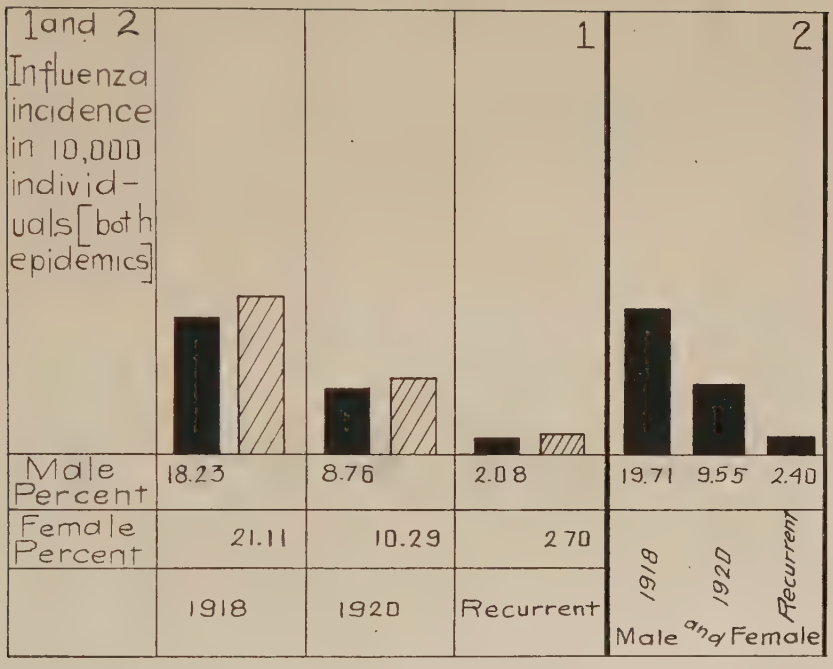
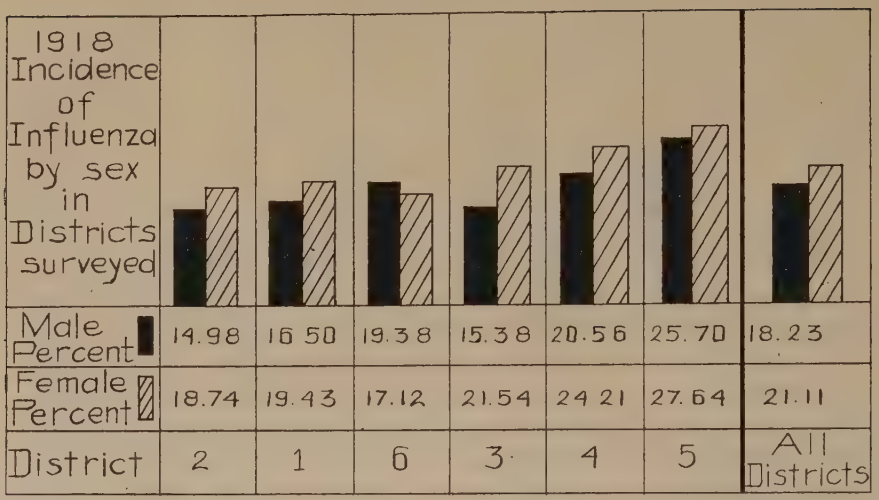
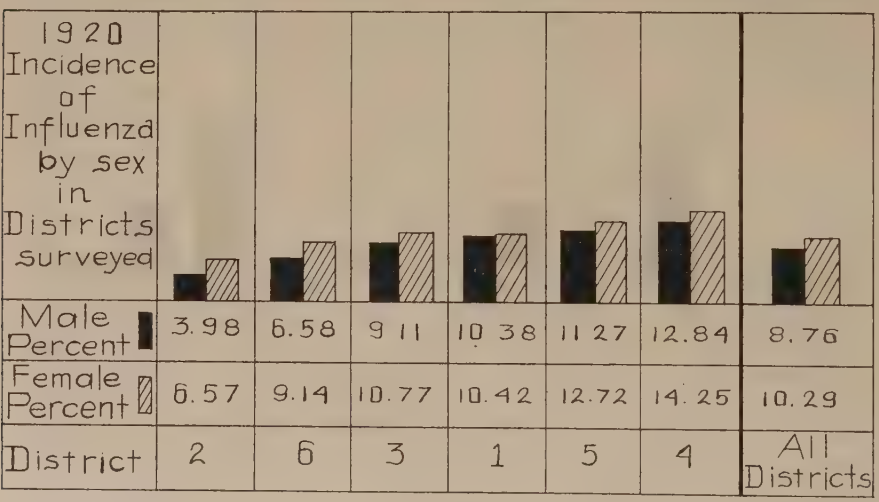

1 and 2
Influenza incidence in 10,000 individuals [both epidemics]
1
2
Male Percent
18.23
8.76
2.08
19.71
9.55
2.40
Female Percent
21.11
10.29
2.70
1918
1920
Recurrent
1918
1920
Recurrent
Male and Female

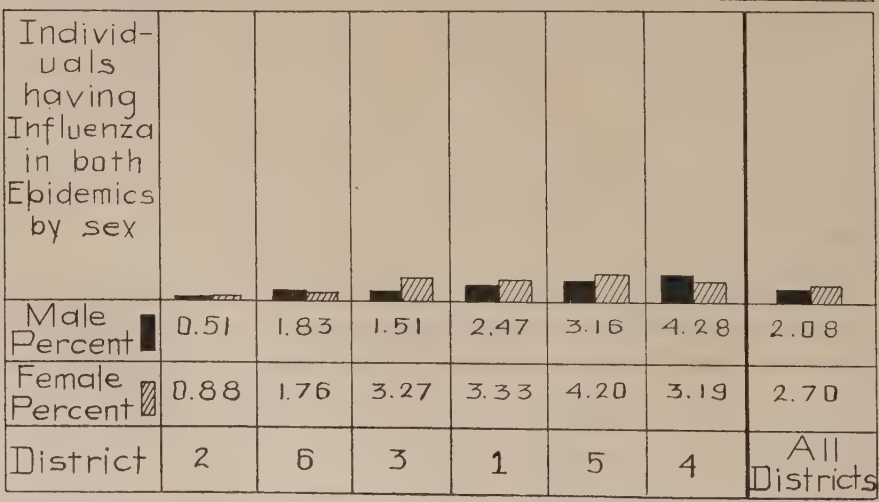
CHART XVI.



Male Percent	14.98	16 50	19.38	15.38	20.56	25.70	18.23
Female Percent	18.74	19.43	17.12	21.54	24 21	27.64	21.11
District	2	1	6	3	4	5	All Districts



Male Percent	3.98	6.58	9 11	10 38	11 27	12.84	8.76
Female Percent	6.57	9.14	10.77	10.42	12.72	14. 25	10.29
District	2	6	3	1	5	4	All Districts



Male Percent	0.51	1.83	1.51	2.47	3.16	4.28	2.08
Female Percent	0.88	1.76	3.27	3.33	4.20	3.19	2.70
District	2	6	3	1	5	4	All Districts

tricts IV and V. Districts I, II and III were in the tenement section of the city, while District VI was in one of the finest residential parts of Brookline. Districts IV and V were midway between these two extremes as regards economic and sanitary status, as well as extent of crowding. The lowest incidence was in the Irish tenement district. The highest in a middle class Jewish population.

In the 1920 recurrence we found that 9.55 per cent., or one-tenth of the entire population, suffered from the disease, and the arrangement of districts in order of incidence was very little changed. The Irish community suffered least; the two middle class communities most. The well-to-do district in Brookline had the next lowest incidence in 1920. That the high recorded incidence in middle class districts was not due to more accurate or more thorough work on the part of the inspectors is indicated by the fact that a great part of the work on Districts IV and V was done by the same individuals who inspected Districts II and III.

One-fifth of the population studied developed the influenza in 1918–19, and one-tenth of the same population suffered in 1920.

We may agree with Winslow and Rogers, who conclude that the proportion of the population actually affected by the influenza epidemic in 1918 varied between 200 and 400 per thousand.

Relation of sex to morbidity.—Abbott concluded from his studies in 1890, that the weight of testimony appears to favor the statement that persons of the male sex were attacked in greater number and with greater severity than females. Leichtenstern reached similar conclusions. In the epidemic of 1889, the males were attacked more frequently than the females. He attributes this to two causes: first, the greater exposure to infection, and; second, the fact that strong, robust individuals are more frequently attacked.

It is amusing to compare this explanation with another found in the Medical Supplement to the Review of the Foreign Press for March, 1919. "A Spanish mission composed of Maranon, Pittaluga and Falco visited Paris last October to collect information as to the identity of the Spanish epidemic with the world pandemic of influenza. They found that the epidemics in France and Spain were absolutely identical from the epidemiologic, bacteriologic and clinical standpoint. The great majority of the severe cases in both countries occurred between the ages of 16 and 40. Both in France and Spain more females than males were attacked, which was possibly explained by the greater tendency of the former to lead an indoor existence."

Jordan, Reed and Fink, working in Chicago, found very different

results. They could discover no noteworthy difference among the pupils in high school and elementary school. The attack rate was 230 for the boys and 231 for girls. One sex was presumably as much exposed as the other.

Among the employees of the Chicago Telephone Company, on the other hand, the men were affected in considerably lighter proportion than the women (151 per 1,000 as compared with 233 per 1,000 for women). Jordan believes that the age factor was largely responsible for the difference as the women employees are as a rule of much lower average age than the men.

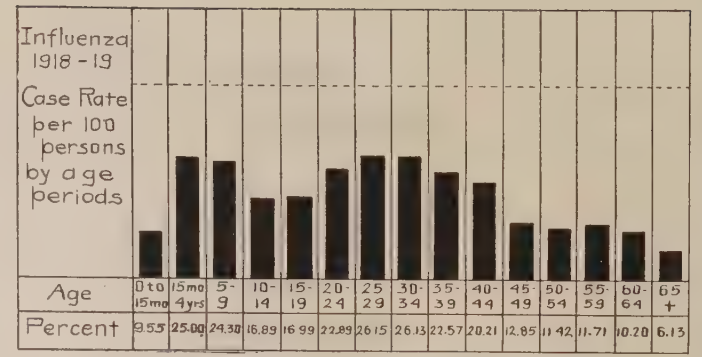
Frost found that with few exceptions the attack rate at all ages was somewhat higher in females than in males. The total excess of incidence in females was six per cent., which ranged from an excess of nineteen per cent. in the highest locality to a deficiency of two per cent. in the lowest. Only two of the eleven localities surveyed showed a lower incidence among females than among males.

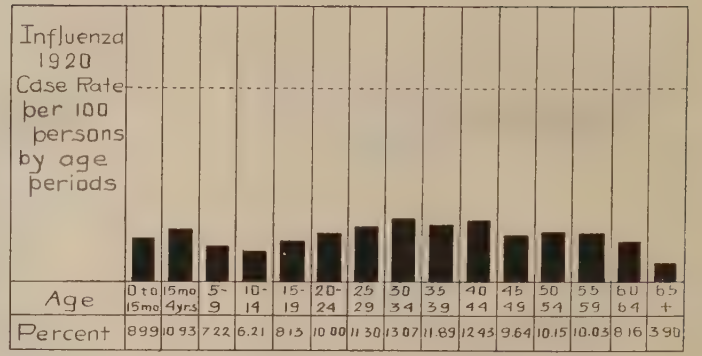
When the sexes were compared in different age groups, the female was found to be higher than the male in each age period except under 5, 10 to 14, 40 to 44, and 70 to 74. The excess of incidence in males in these groups is relatively small, and is hardly significant in the highest age groups, where the rates are computed from small figures. Frost found the most striking excess of incidence in females occurring between the ages of fifteen and forty, the difference between the sexes being relatively slight in age periods above and below these limits. Females over the age of fifteen and especially between the ages of 15 and 45 were either more susceptible to infection, or more generally and more intimately exposed than males of corresponding age.

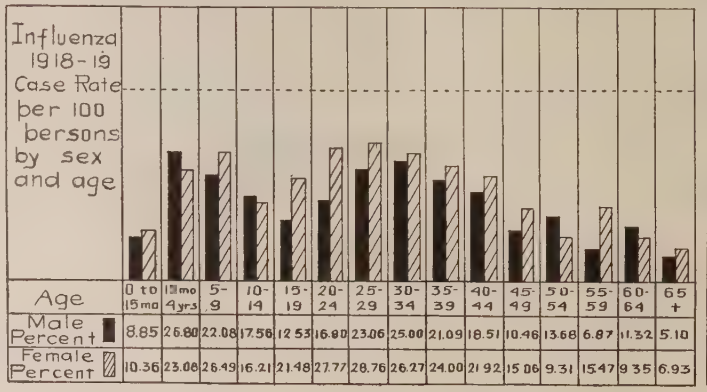
Our own records by the different age groups were remarkably similar. We have found an excess among the females in every age except under five years, 10 to 14, 50 to 54, and 60 to 64. In 1920 we found a slight excess among the males up to the age of 15, and again at the ages 55 to 65. Females predominated in all other ages (Chart XVII). Among those individuals who had attacks of influenza during both epidemics females again predominated except in the ages under 5 years, 10 to 14 and 55 to 59. In our own results we find that ages above 65 show a predominance of females.

After considering both series of results it is safe to generalize in saying that above the age of 15 the female sex tends to acquire the disease in slightly greater proportion than the male sex.

Chart XV shows the predominance of the female incidence in both epidemics.


Influenza
1918-19
Case Rate
per 100
persons
by age
periods
Age
0 to 15mo
15mo 4yrs
5-9
10-14
15-19
20-24
25-29
30-34
35-39
40-44
45-49
50-54
55-59
60-64
65+
Percent
9.55
25.00
24.30
16.89
16.99
22.89
26.15
26.13
22.57
20.21
12.85
11.42
11.71
10.20
6.13


Influenza
1920
Case Rate
per 100
persons
by age
periods
Age
0 to 15mo
15mo 4yrs
5-9
10-14
15-19
20-24
25-29
30-34
35-39
40-44
45-49
50-54
55-59
60-64
65+
Percent
8.99
10.93
7.22
6.21
8.13
10.00
11.30
13.07
11.89
12.43
9.64
10.15
10.03
8.16
3.90


Influenza
1918-19
Case Rate
per 100
persons
by sex
and age
Age
0 to 15mo
15mo 4yrs
5-9
10-14
15-19
20-24
25-29
30-34
35-39
40-44
45-49
50-54
55-59
60-64
65+
Male
Percent
8.85
26.80
22.08
17.56
12.53
16.80
23.06
25.00
21.09
18.51
10.46
13.68
6.87
11.32
5.10
Female
Percent
10.36
23.06
26.49
16.21
21.48
27.77
28.76
26.27
24.00
21.92
15.06
9.31
15.47
9.35
6.93

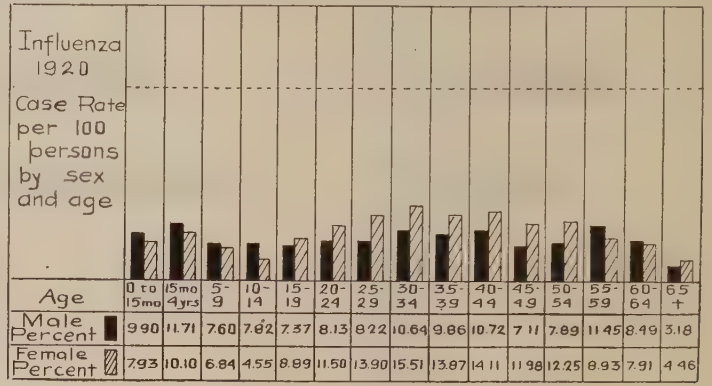

Influenza
1920
Case Rate
per 100
persons
by sex
and age
Age
0 to 15mo
15mo 4yrs
5-9
10-14
15-19
20-24
25-29
30-34
35-39
40-44
45-49
50-54
55-59
60-64
65+
Male
Percent
9.90
11.71
7.60
7.62
7.37
8.13
8.22
10.64
9.86
10.72
7.11
7.89
11.45
8.49
3.18
Female
Percent
7.93
10.10
6.84
4.55
8.89
11.50
13.90
15.51
13.87
14.11
11.98
12.25
8.93
7.91
4.46

CHART XVII.

CHART XVIII.

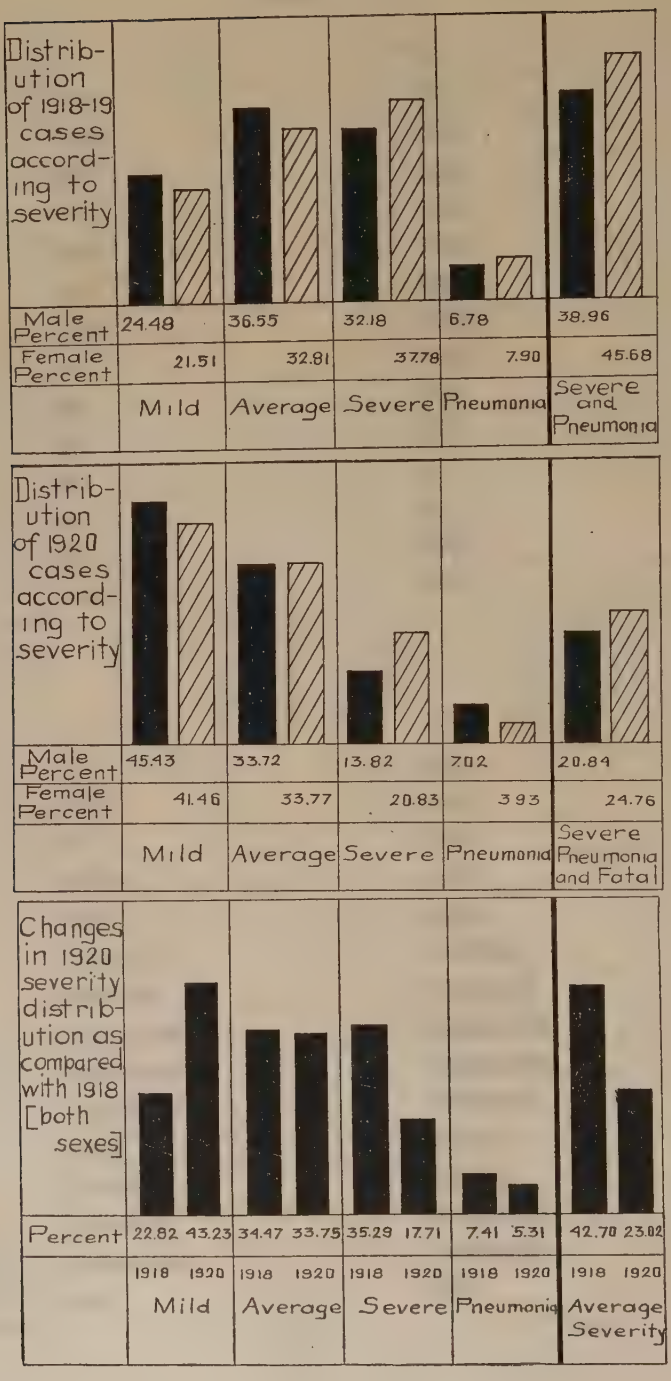
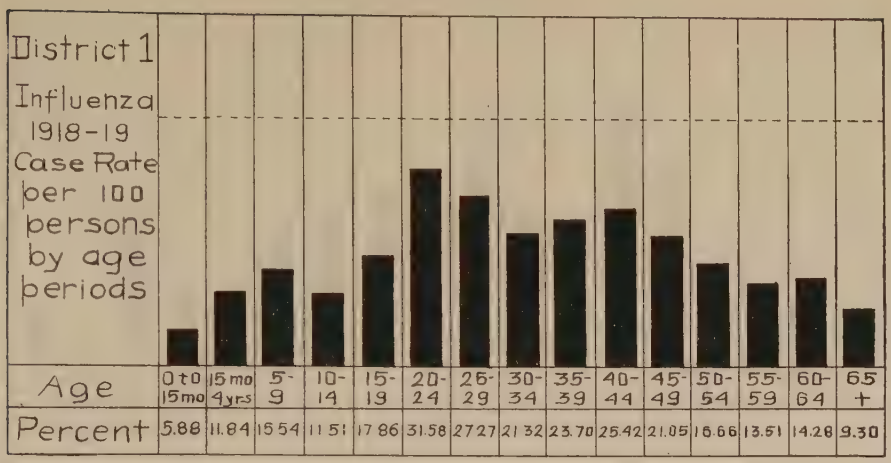
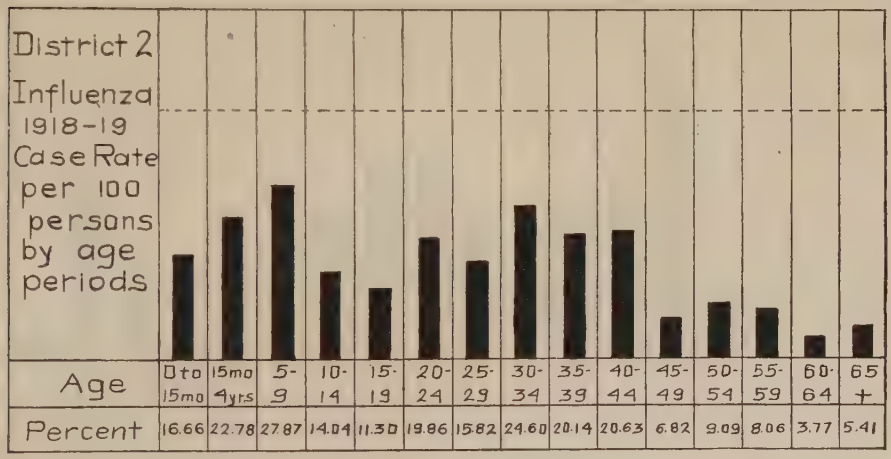

Distribution of 1918-19 cases according to severity
Male Percent
24.48
36.55
32.18
6.78
38.96
Female Percent
21.51
32.81
37.78
7.90
45.68
Mild
Average
Severe
Pneumonia
Severe and Pneumonia
Distribution of 1920 cases according to severity
Male Percent
45.43
33.72
13.82
7.02
20.84
Female Percent
41.46
33.77
20.83
3.93
24.76
Mild
Average
Severe
Pneumonia
Severe Pneumonia and Fatal
Changes in 1920 severity distribution as compared with 1918 [both sexes]
Percent
22.82 43.23
34.47 33.75
35.29 17.71
7.41 5.31
42.70 23.02
1918 1920
Mild
1918 1920
Average
1918 1920
Severe
1918 1920
Pneumonia
1918 1920
Average Severity

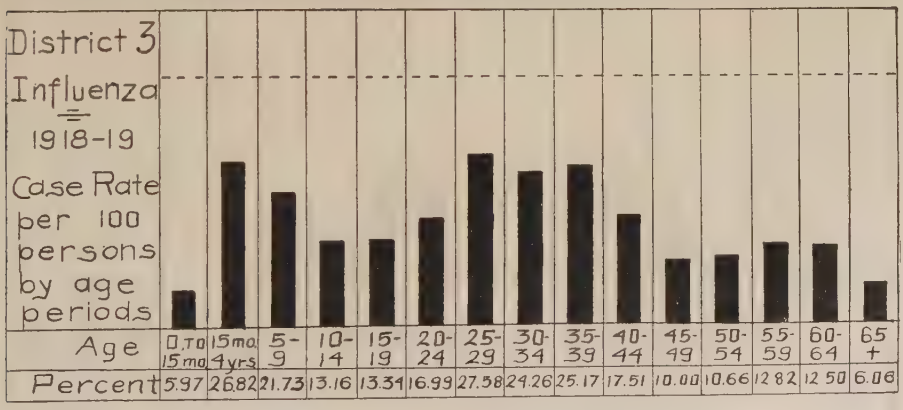
CHART XIX.



Age	0 to 15 mo	15 mo 4 yrs	5-9	10-14	15-19	20-24	25-29	30-34	35-39	40-44	45-49	50-54	55-59	60-64	65 +
Percent	5.88	11.84	15.54	11.51	17.86	31.58	27.27	21.32	23.70	25.42	21.05	16.66	13.51	14.28	9.30

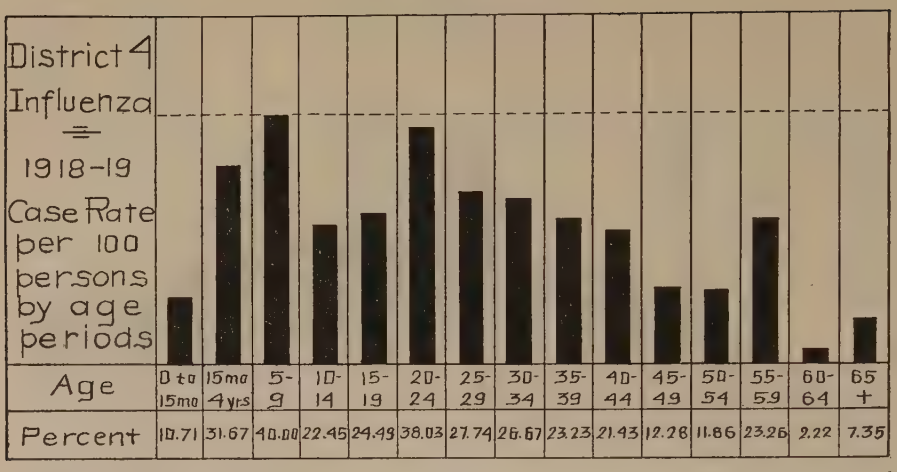


Age	0 to 15 mo	15 mo 4 yrs	5-9	10-14	15-19	20-24	25-29	30-34	35-39	40-44	45-49	50-54	55-59	60-64	65 +
Percent	16.66	22.78	27.87	14.04	11.30	19.86	15.82	24.60	20.14	20.63	6.82	9.09	8.06	3.77	5.41

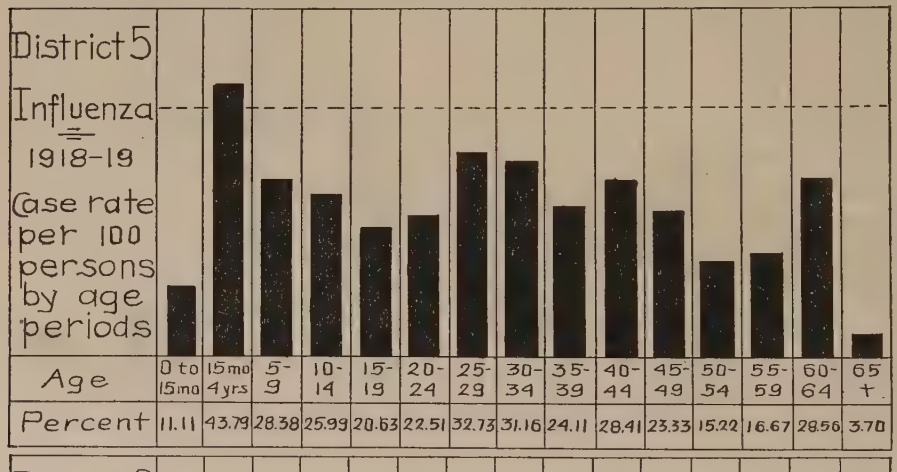


Age	0 to 15 mo	15 mo 4 yrs	5-9	10-14	15-19	20-24	25-29	30-34	35-39	40-44	45-49	50-54	55-59	60-64	65 +
Percent	5.97	26.82	21.73	13.16	13.31	16.99	27.58	24.26	25.17	17.51	10.00	10.66	12.82	12.50	6.06

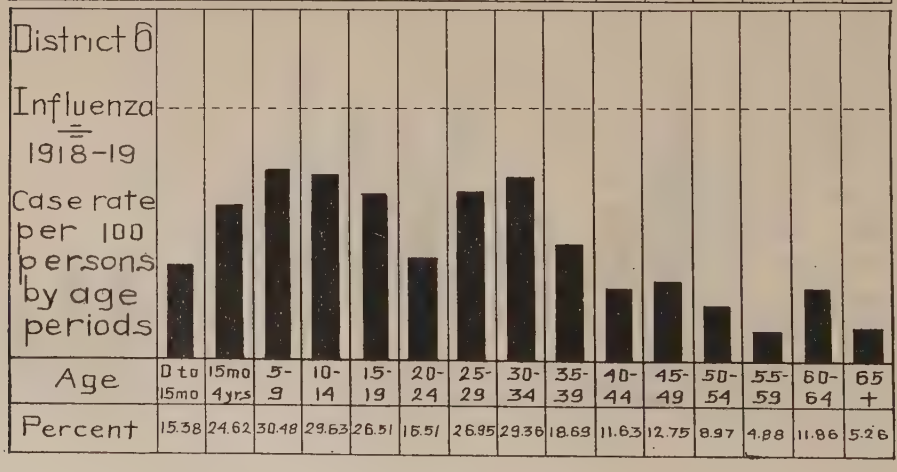
CHART XIX.—(*Cont.*)



Age	0 to 15mo	15mo 4yrs	5-9	10-14	15-19	20-24	25-29	30-34	35-39	40-44	45-49	50-54	55-59	60-64	65+
Percent	10.71	31.67	40.00	22.45	24.49	38.03	27.74	26.67	23.23	21.43	12.28	11.86	23.26	2.22	7.35

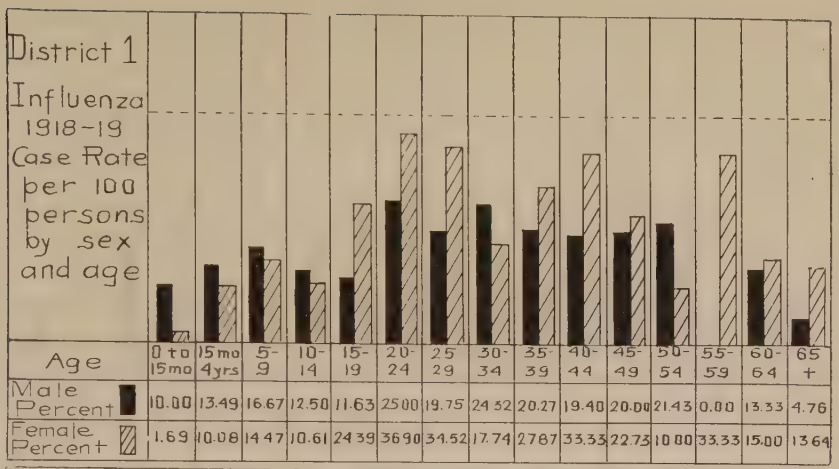


Age	0 to 15mo	15mo 4yrs	5-9	10-14	15-19	20-24	25-29	30-34	35-39	40-44	45-49	50-54	55-59	60-64	65+
Percent	11.11	43.79	28.38	25.99	20.63	22.51	32.73	31.16	24.11	28.41	23.33	15.22	16.67	28.56	3.70

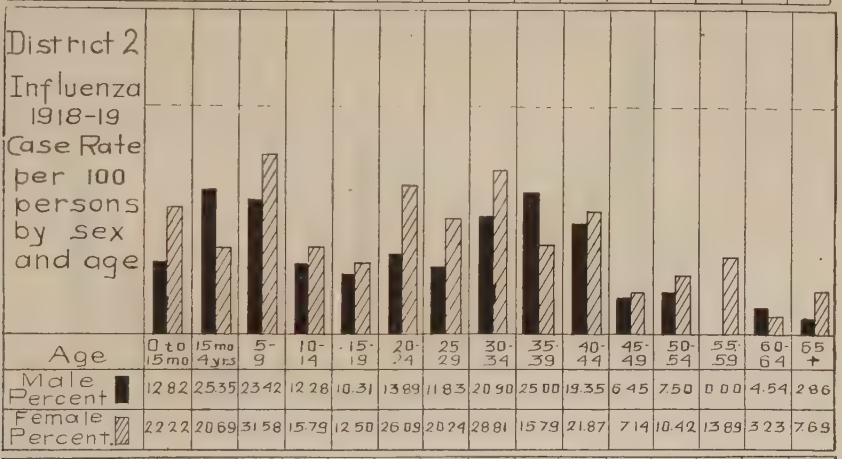


Age	0 to 15mo	15mo 4yrs	5-9	10-14	15-19	20-24	25-29	30-34	35-39	40-44	45-49	50-54	55-59	60-64	65+
Percent	15.38	24.62	30.48	29.63	26.51	16.51	26.95	29.36	18.63	11.63	12.75	8.97	4.88	11.86	5.26

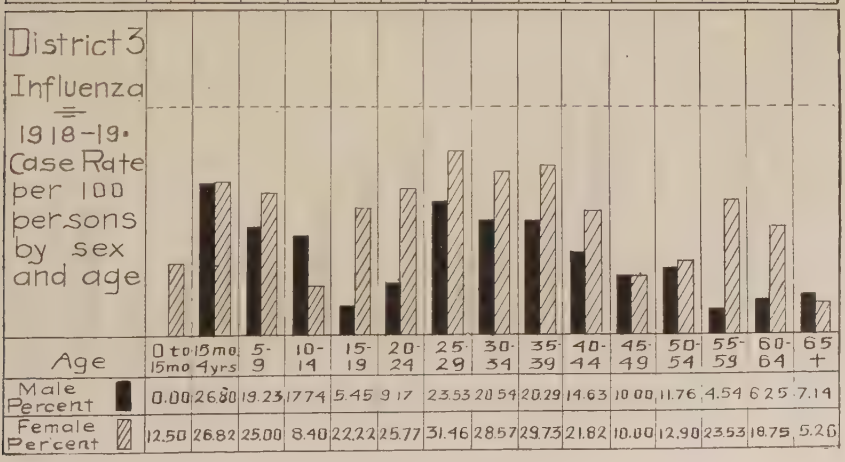
CHART XX.



Age	0 to 15mo	15mo 4yrs	5-9	10-14	15-19	20-24	25-29	30-34	35-39	40-44	45-49	50-54	55-59	60-64	65+
Male Percent	10.00	13.49	16.67	12.50	11.63	25.00	19.75	24.32	20.27	19.40	20.00	21.43	0.00	13.33	4.76
Female Percent	1.69	10.08	14.47	10.61	24.39	36.90	34.52	17.74	27.87	33.33	22.73	10.00	33.33	15.00	13.64

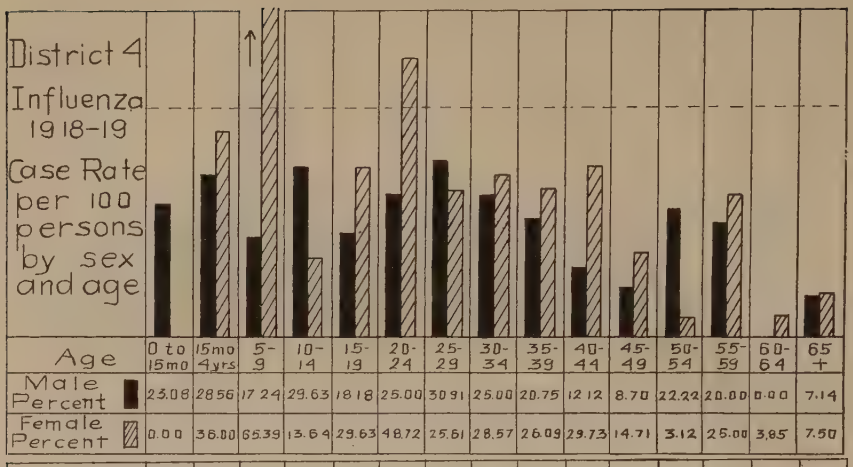


Age	0 to 15mo	15mo 4yrs	5-9	10-14	15-19	20-24	25-29	30-34	35-39	40-44	45-49	50-54	55-59	60-64	65+
Male Percent	12.82	25.35	23.42	12.28	10.31	13.89	11.83	20.90	25.00	19.35	6.45	7.50	0.00	4.54	2.86
Female Percent	22.22	20.69	31.58	15.79	12.50	26.09	20.24	28.81	15.79	21.87	7.14	10.42	13.89	3.23	7.69

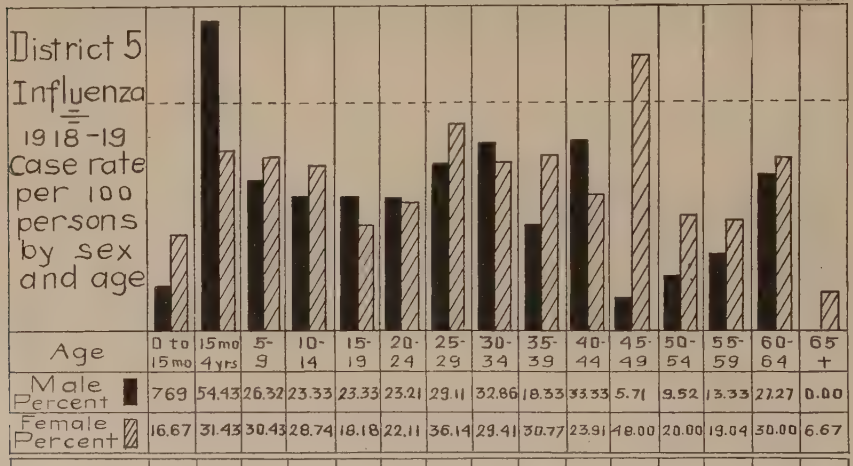


Age	0 to 15mo	15mo 4yrs	5-9	10-14	15-19	20-24	25-29	30-34	35-39	40-44	45-49	50-54	55-59	60-64	65+
Male Percent	0.00	26.80	19.23	17.74	5.45	9.17	23.53	20.54	20.29	14.63	10.00	11.76	4.54	6.25	7.14
Female Percent	12.50	26.82	25.00	8.40	22.22	25.77	31.46	28.57	29.73	21.82	10.00	12.90	23.53	18.75	5.26

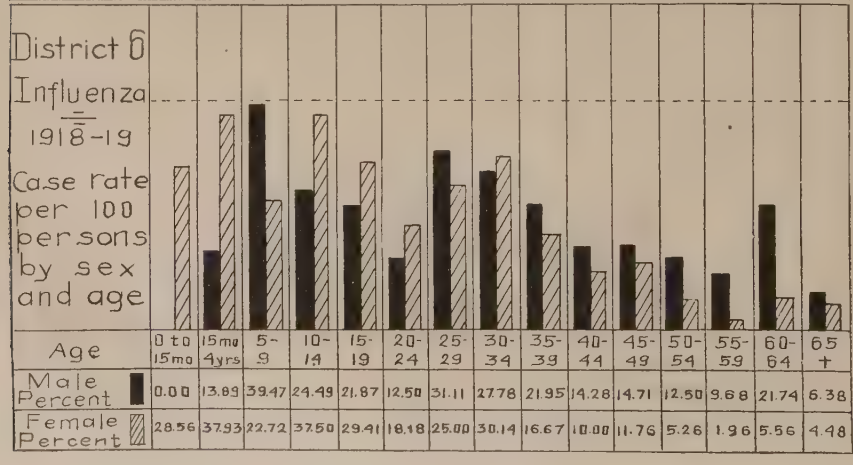
CHART XX.—(*Cont.*)



Age	0 to 15mo	15mo 4yrs	5-9	10-14	15-19	20-24	25-29	30-34	35-39	40-44	45-49	50-54	55-59	60-64	65+
Male Percent	23.08	28.56	17.24	29.63	18.18	25.00	30.91	25.00	20.75	12.12	8.70	22.22	20.00	0.00	7.14
Female Percent	0.00	36.00	65.39	13.64	29.63	48.72	25.61	28.57	26.09	29.73	14.71	3.12	25.00	3.85	7.50

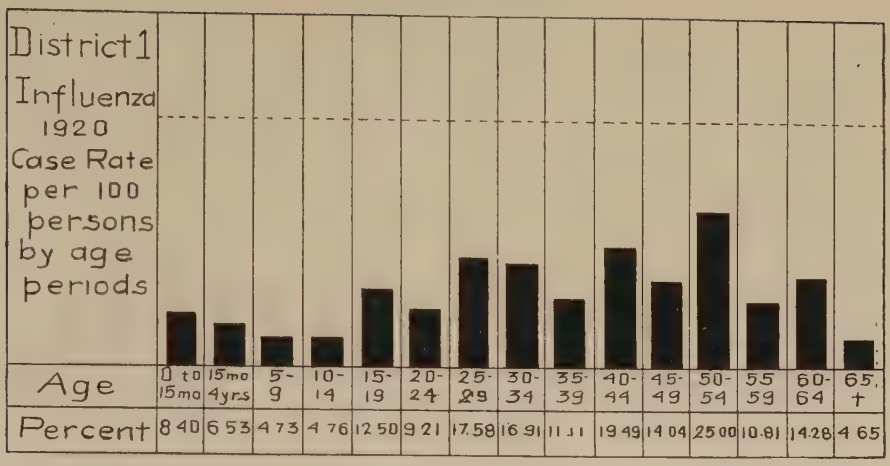


Age	0 to 15mo	15mo 4yrs	5-9	10-14	15-19	20-24	25-29	30-34	35-39	40-44	45-49	50-54	55-59	60-64	65+
Male Percent	7.69	54.43	26.32	23.33	23.33	23.21	29.11	32.86	18.33	33.33	5.71	9.52	13.33	27.27	0.00
Female Percent	16.67	31.43	30.43	28.74	18.18	22.11	36.14	29.41	30.77	23.91	48.00	20.00	19.04	30.00	6.67

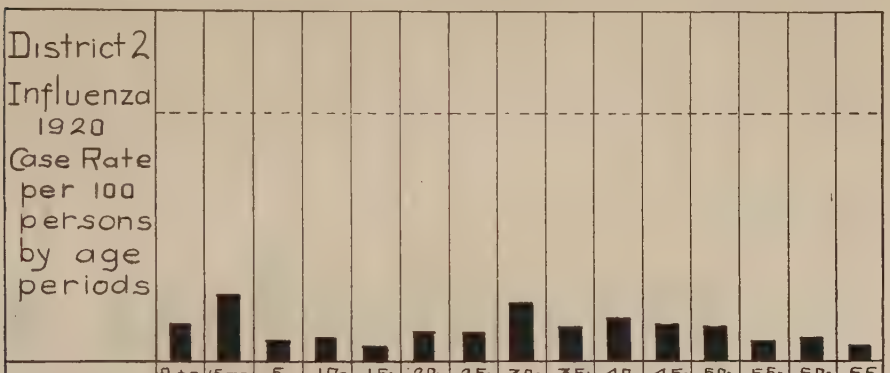


Age	0 to 15mo	15mo 4yrs	5-9	10-14	15-19	20-24	25-29	30-34	35-39	40-44	45-49	50-54	55-59	60-64	65+
Male Percent	0.00	13.89	39.47	24.49	21.87	12.50	31.11	27.78	21.95	14.28	14.71	12.50	9.68	21.74	6.38
Female Percent	28.56	37.93	22.72	37.50	29.41	18.18	25.00	30.14	16.67	10.00	11.76	5.26	1.96	5.56	4.48

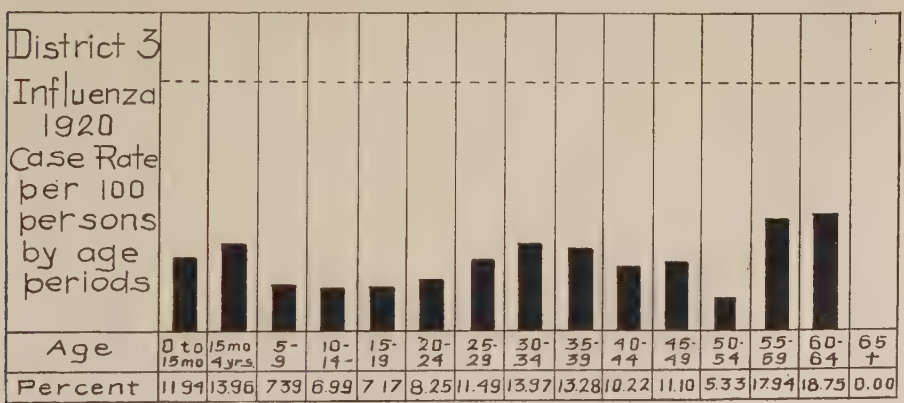
CHART XXI.



Age	0 to 15mo	15mo 4yrs	5-9	10-14	15-19	20-24	25-29	30-34	35-39	40-44	45-49	50-54	55-59	60-64	65+
Percent	8.40	6.53	4.73	4.76	12.50	9.21	17.58	16.91	11.31	19.49	14.04	25.00	10.81	14.28	4.65

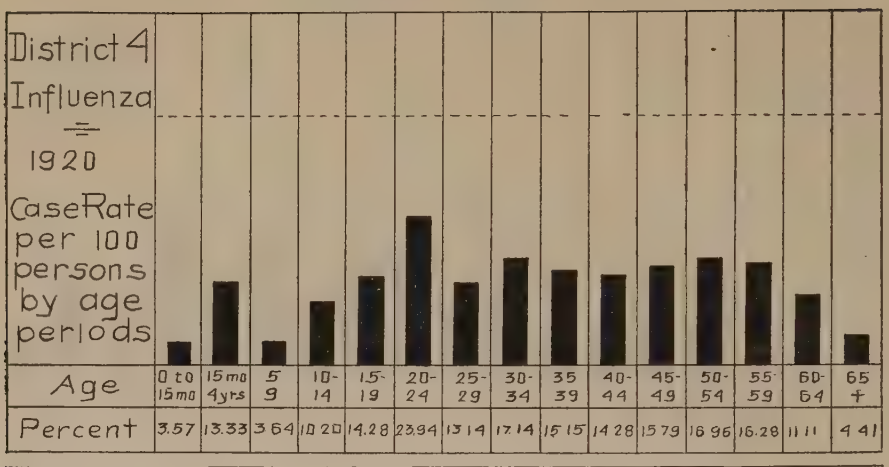


Age	0 to 15mo.	15mo 4yrs	5-9	10-14	15-19	20-24	25-29	30-34	35-39	40-44	45-49	50-54	55-59	60-64	65+
Percent	6.06	10.76	3.69	3.95	2.26	4.96	4.52	9.52	5.55	7.14	6.06	5.68	3.22	3.77	2.70

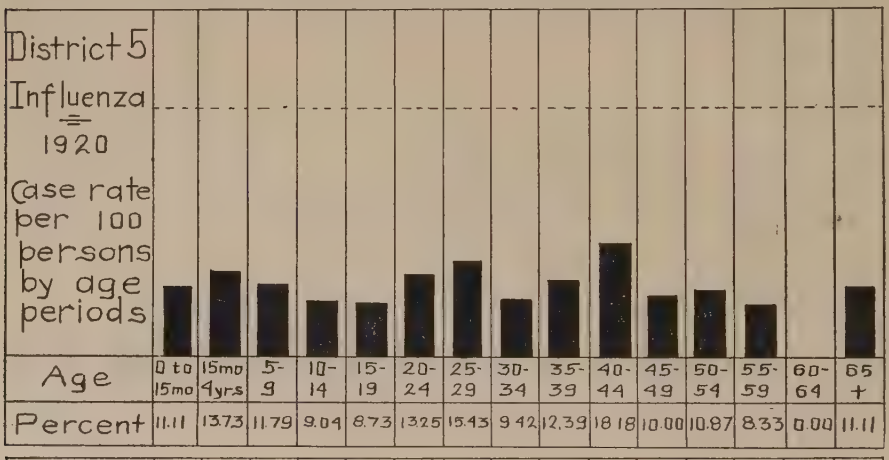


Age	0 to 15mo	15mo 4yrs	5-9	10-14	15-19	20-24	25-29	30-34	35-39	40-44	45-49	50-54	55-59	60-64	65+
Percent	11.94	13.96	7.39	6.99	7.17	8.25	11.49	13.97	13.28	10.22	11.10	5.33	17.94	18.75	0.00

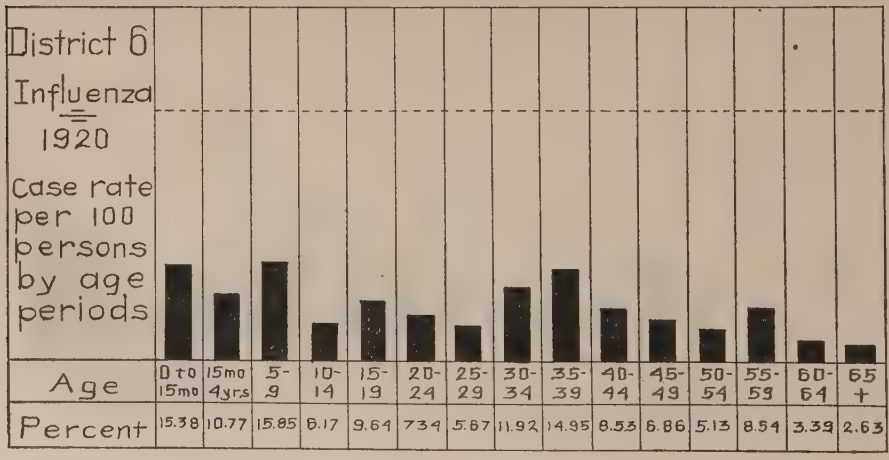
CHART XXI.—(*Cont.*)



Age	0 to 15mo	15mo 4yrs	5-9	10-14	15-19	20-24	25-29	30-34	35-39	40-44	45-49	50-54	55-59	60-64	65+
Percent	3.57	13.33	3.64	10.20	14.28	23.94	13.14	17.14	15.15	14.28	15.79	16.96	16.28	11.11	4.41



Age	0 to 15mo	15mo 4yrs	5-9	10-14	15-19	20-24	25-29	30-34	35-39	40-44	45-49	50-54	55-59	60-64	65+
Percent	11.11	13.73	11.79	9.04	8.73	13.25	15.43	9.42	12.39	18.18	10.00	10.87	8.33	0.00	11.11



Age	0 to 15mo	15mo 4yrs	5-9	10-14	15-19	20-24	25-29	30-34	35-39	40-44	45-49	50-54	55-59	60-64	65+
Percent	15.38	10.77	15.85	8.17	9.64	7.34	5.67	11.92	14.95	8.53	6.86	5.13	8.54	3.39	2.63

Relationship of sex to severity.—In classifying cases as to severity, we have followed the standard previously described. Our results have shown that the 1920 recurrence in our group of individuals has been decidedly milder than the earlier 1918 spread. The proportion of mild cases in 1920 is nearly twice that of mild attacks in 1918–19. The proportion of severe cases was twice as great in 1918 as in 1920. The actual severity in 1918 was even greater than would be indicated by these figures. The last column in Chart XVIII is a combination of the two preceding, and while the 1920 column includes all classed as severe, pneumonia, and fatal, that for 1918 only includes the severe and pneumonia cases, but does not include the fatal cases for that year, because those who died during the 1918–19 epidemics are not counted in our 10,000 individuals surveyed. If these were included the percentage of total severe, or average severity would be greater than 42.70.

We find that in 1918 the female sex had a higher proportion of severe cases according to our standard than did the male. This was equally true in 1920. We should emphasize here that we are not comparing only the fatal cases in the two sexes, but all classified as severe, and including fatal in 1920.

Not only was the female sex attacked in slightly greater proportion, but also the individual cases appear to have been on the aggregate somewhat more severe in that sex.

Morbidity by age.—Before discussing the incidence of influenza in the various age periods we should explain that the charts for 1920 are based on the ages given by the individuals, and those for 1918 upon these ages, corrected by the subtraction of 15 months from the age as given. In our study of cases recurring during both epidemics the age used in the calculations is that of 1920. It is for this reason that in all of our age charts we have a first age period from zero to 15 months. Infants of less than 15 months at the time of our survey were born subsequent to the peak of the 1918–19 epidemic, and are not included in computations for that time.

The general similarity of the age-incidence in the six districts studied (Charts XIX and XX) is evident. As a rule two peaks can be discerned, one falling somewhere between 15 months and 9 years, and the other between 20 and 39 years. There are individual variations in the different districts, and in Districts IV, V and VI there is a tendency toward a peak in the period 55 to 64. This, however, disappears when the total 10,000 is tabulated, when the two peaks, 15 months to 9 years, and 20 to 39, show out clearly for the year 1918 (Chart XVII).

Frost found for the same epidemic that the attack rate was highest in the age group 5 to 9, declining with almost unbroken regularity in each successive higher age group, with the exception of the groups 25 to 34, in which the attack rates were higher than in the age groups 15 to 24, but not as high as that of 5 to 9.

Both series of observations agree in finding relatively high incidence in early childhood and in early adult life.

For 1920 (Chart XVII) we find that these peaks, although present, have become decidedly less prominent, and that there is a relatively higher incidence in individuals past the age of 40 (Charts XXI and XXII). There is some tendency toward straightening out of the curve; age appears to have played a less important part, and those higher ages which were relatively insusceptible in 1918 have become more susceptible in 1920. We cannot generalize in the statement that all ages which were lightly attacked in the first epidemic were more severely attacked in the 1920 spread, because the ages from 10 to 19 are found to be relatively lower during both epidemics.

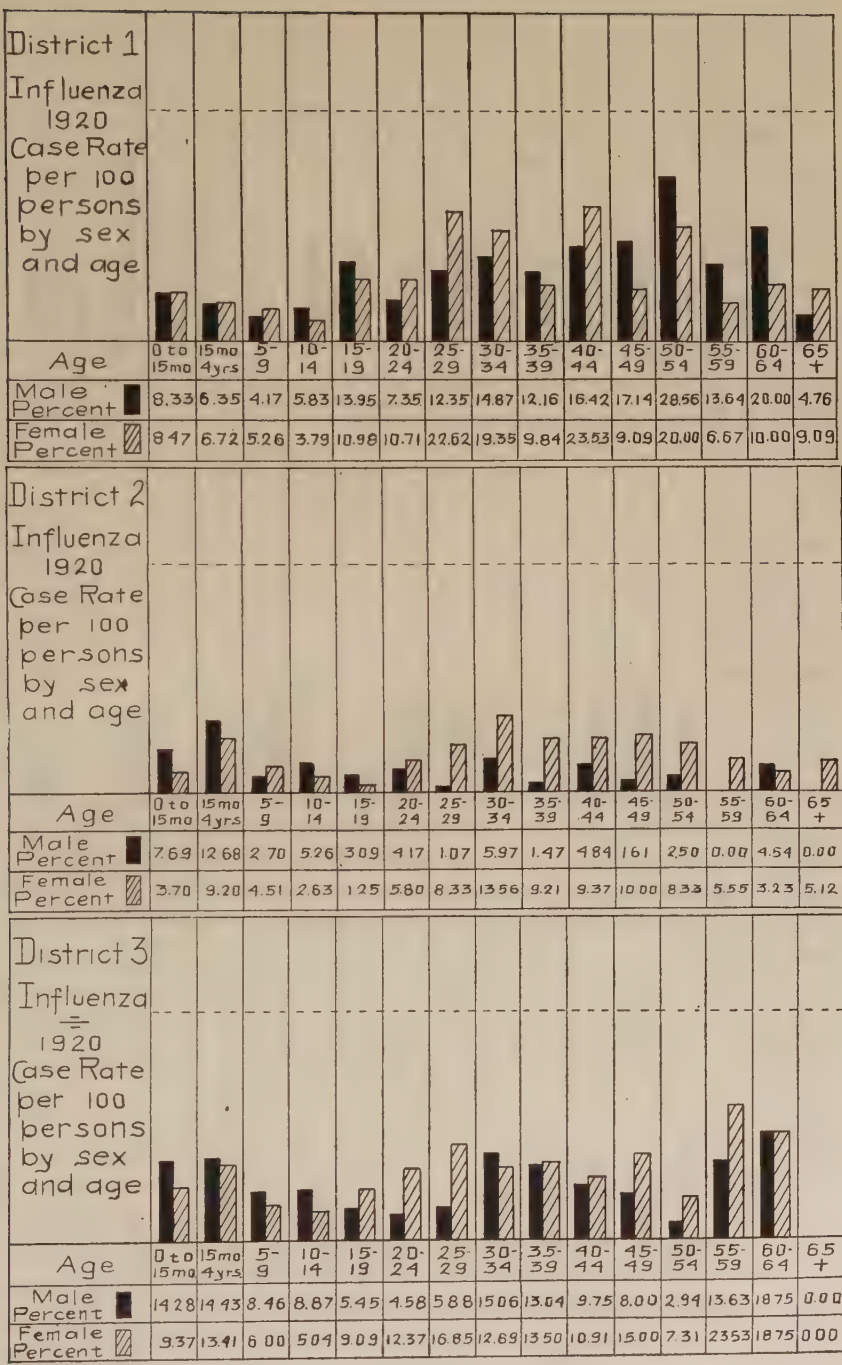
Other observations have been made regarding the age incidence particularly during the 1918 pandemic. Jordan's figures for the October epidemic show a higher incidence among school children of ages 4–13 than among those of higher school age, 14–18. The teachers in these schools had a lower attack rate than the pupils. The pupils in both school groups were from the same section of the city and to a large extent from the same families and were presumably exposed in similar degree.

Lynch and Cumming found that of 49,140 children in public institutions the influenza rate was 412 per 1,000, while among 703,006 adults in similar institutions the rate was 263 per 1,000. These figures include children in a large number of institutions scattered throughout the United States, and would indicate that in childhood the susceptibility is much greater than in adults.

Many writers agree that nursing infants show a relative insusceptibility. However Abt records a case of an expectant mother who, within two weeks of term, developed influenza, and during the course of her illness gave birth to a baby boy, who at birth was found to be suffering from bronchitis and bronchopneumonia, but who lived for three days, finally dying of bronchopneumonia. Abt concludes from a review of all of the facts that the newly born infant had influenza and that the baby had become infected before birth.

According to Carnwath, the age incidence showed curious changes. During the 1918 summer wave the ages most affected were 15 to 45.

CHART XXII.

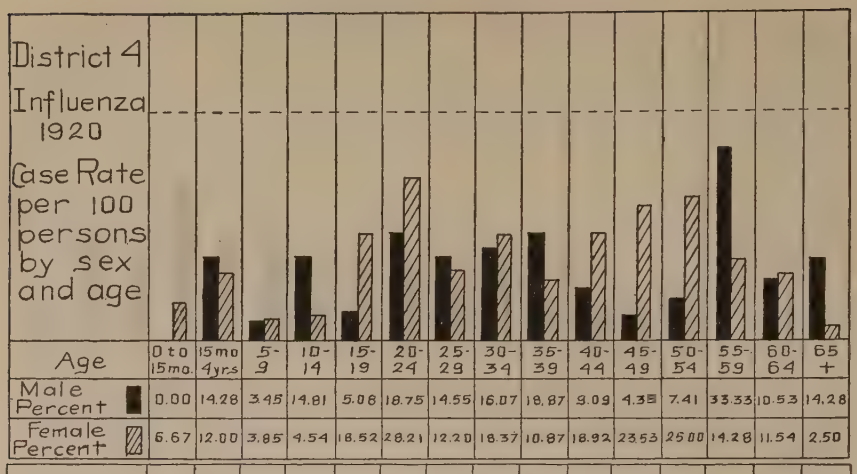


District 1 — Age	0 to 15mo	15mo 4yrs	5-9	10-14	15-19	20-24	25-29	30-34	35-39	40-44	45-49	50-54	55-59	60-64	65+
Male Percent	8.33	6.35	4.17	5.83	13.95	7.35	12.35	14.87	12.16	16.42	17.14	28.56	13.64	20.00	4.76
Female Percent	8.47	6.72	5.26	3.79	10.98	10.71	22.62	19.35	9.84	23.53	9.09	20.00	6.67	10.00	9.09

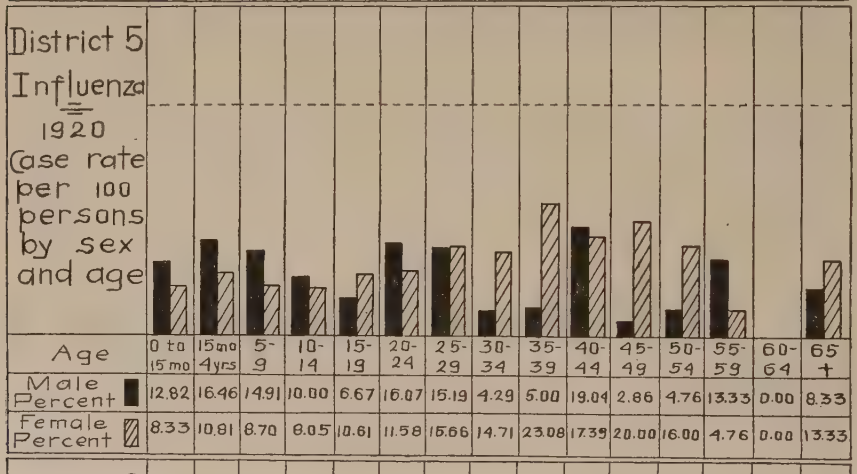
District 2 — Age	0 to 15mo	15mo 4yrs	5-9	10-14	15-19	20-24	25-29	30-34	35-39	40-44	45-49	50-54	55-59	60-64	65+
Male Percent	7.69	12.68	2.70	5.26	3.09	4.17	1.07	5.97	1.47	4.84	1.61	2.50	0.00	4.54	0.00
Female Percent	3.70	9.20	4.51	2.63	1.25	5.80	8.33	13.56	9.21	9.37	10.00	8.33	5.55	3.23	5.12

District 3 — Age	0 to 15mo	15mo 4yrs	5-9	10-14	15-19	20-24	25-29	30-34	35-39	40-44	45-49	50-54	55-59	60-64	65+
Male Percent	14.28	14.93	8.46	8.87	5.45	4.58	5.88	15.06	13.04	9.75	8.00	2.94	13.63	18.75	0.00
Female Percent	9.37	13.41	6.00	5.04	9.09	12.37	16.85	12.69	13.50	10.91	15.00	7.31	23.53	18.75	0.00

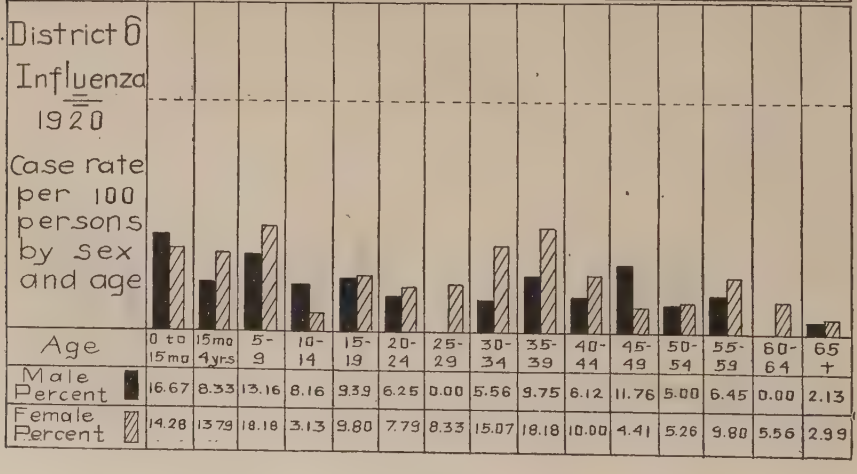
CHART XXII.—(*Cont.*)



Age	0 to 15 mo.	15 mo 4 yrs	5-9	10-14	15-19	20-24	25-29	30-34	35-39	40-44	45-49	50-54	55-59	60-64	65+
Male Percent	0.00	14.28	3.45	14.81	5.08	18.75	14.55	16.07	18.87	9.09	4.35	7.41	33.33	10.53	14.28
Female Percent	6.67	12.00	3.85	4.54	18.52	28.21	12.20	18.37	10.87	18.92	23.53	25.00	14.28	11.54	2.50



Age	0 to 15 mo	15 mo 4 yrs	5-9	10-14	15-19	20-24	25-29	30-34	35-39	40-44	45-49	50-54	55-59	60-64	65+
Male Percent	12.82	16.46	14.91	10.00	6.67	16.07	15.19	4.29	5.00	19.04	2.86	4.76	13.33	0.00	8.33
Female Percent	8.33	10.81	8.70	8.05	10.61	11.58	15.66	14.71	23.08	17.39	20.00	16.00	4.76	0.00	13.33



Age	0 to 15 mo	15 mo 4 yrs	5-9	10-14	15-19	20-24	25-29	30-34	35-39	40-44	45-49	50-54	55-59	60-64	65+
Male Percent	16.67	8.33	13.16	8.16	9.39	6.25	0.00	5.56	9.75	6.12	11.76	5.00	6.45	0.00	2.13
Female Percent	14.28	13.79	18.18	3.13	9.80	7.79	8.33	15.07	18.18	10.00	4.41	5.26	9.80	5.56	2.99

In the winter of 1918–19 there was a considerable shifting toward the extremes of life and particularly toward the younger years. The susceptibility of young children was the subject of a special inquiry in London. Though the attack rate was below the average, the chances of recovery were less than in other age groups. Of breast-fed infants, 30 per cent. contracted the disease; of artificially-fed 54 per cent. The opposite, however, occurred in lying-in homes. An inquiry in Cheshire revealed that 25.4 per cent. of expectant mothers affected died.

Renon and Mignot have made a report on the 1920 recurrence. According to them the grip of 1920 attacked all ages, in contradistinction to the 1918 epidemic, which attacked especially the young and vigorous. One-third of their group were over 40 years of age, while some were 70 and 80 years old. In spite of this the disease remained relatively mild.

Age morbidity in previous epidemics.—Previous to the epidemic of 1889–93, the various recorded observations regarding morbidity, and particularly regarding age morbidity, have consisted often of records made by practising physicians, and are merely estimates based upon their clinical experience and varying with the type of individual treated by them. Or else they have been records made by non-medical historians. During the 19th century, the tendency toward statistical enumeration becomes more and more prominent, but the first statistical studies of real value to the epidemiologist were made in the epidemic of thirty years ago. Statistical study must begin with this last epidemic. Observations of the earlier epidemics, while very interesting for reference and comparison, are no longer acceptable as unquestioned statements of fact. Even at the present time and with all of the emphasis that is now being laid upon statistical procedure the records are far from perfect, and it is to be hoped that in years to come the improvement will be so decided that the records even of the 1918–20 epidemics will appear crude.

Buoninsegni remarks of the 1387 epidemic that many individuals of all ages died, but the deaths were particularly prevalent among the aged.

Jacob, of Königshofen, writes that "there came a general pestilence in the whole country, with cough and influenza, so that hardly one among ten remained healthy," and that old and debilitated persons were frequently the victims.

Balioanus tells us that the epidemic of 1404 let not rank, age nor sex escape its effect.

In 1557,according to Valleriola, the disease appeared with pestilential rapidity, and spared neither sex, nor any age, nor rank, neither

children nor old persons, rich nor poor, but that it was not as a general rule dangerous; children only, who could not freely cough out the phlegm, dying.

The same story is told by Molineux, for 1693, "All conditions of persons were attacked, those residing in the country as well as those in the city; those who lived in the fresh air and those who kept to their rooms; those who were very strong and hardy were taken in the same manner as the weak and spoiled; men, women and children, persons of all ranks and stations in life, the youngest as well as the oldest." Molineux, however, added that, "it rather favored the very old who seldom were attacked with it."

These observations are but broad generalizations; if we pause to study the psychology of the historian we are tempted to conclude that his primary object was to impress his readers with an idea of the enormousness of the dissemination of the disease during his period. That being the main endeavor, a tendency to exaggerate for the sake of rhetoric and yet remain within the limits of truth may be considered excusable. But during the 1889–93 epidemic there was ample opportunity to compare the estimates made by the practising physicians with the later statistical tabulations. As a rule the former were higher both as regards morbidity and mortality.

In the 1830–32 epidemic an interesting observation has been made. While Kahlert says that no distinction between age, sex nor rank occurred, Leberscht stated that persons of middle age, especially women in the climacteric period, were attacked with special frequency. This is of interest in view of the findings in the 1918 epidemic. Krimer states for the same epidemic that children under 14 years of age and adults over 45 years were spared by the epidemic.

For the 1836–37 epidemic Finkler records the following: "Most of the patients were adults from 20 to 40 years of age, and of these more women than men were attacked. Curiously, however, the physicians of Würtenberg speak of the great dissemination of the disease among children."

In 1847–48, among the adult influenza patients, there are said to have been more women than men. According to Canstatt, there were proportionately more children than adults attacked.

In 1889–90, according to Finkler, no age was spared, but persons between 20 and 50 years of age were attacked by preference. No trade was a sure protection. The course of the disease in general was favorable and also quite rapid, unfavorable only in many children during the first few years of life, in many old people, in many debilitated persons, and especially in those suffering from chest affections.

An interesting table of this kind is given us by Leichtenstern. His hospital material included 439 influenza patients, and these he carefully grouped according to age.

Age.	Influenza admissions, per cent.	General average of admissions, per cent.
Under 10 years	0.9	0.7
10–20 years	14.7	8.8
20–30 years	40.3	27.5
30–40 years	19.1	23.3
40–50 years	10.1	15.7
50–60 years	7.4	12.3
60–70 years	5.3	8.9
70–80 years	1.7	2.6
Above 80 years	0.4	0.2

Comby found that in Paris only the new-born were noticeably insusceptible to influenza, that children up to 15 years were attacked in the proportion of 40 per cent., and adults in the proportion of 60 per cent. Danchez believed that in families in which all the adults became ill, the little children usually escaped.

Finkler states that in the schools at Bordeaux the older children were first and most frequently attacked. Of the 248 male and female teachers in 41 schools, 153 (61.7 per cent.) developed the disease. Children up to five or six years of age at any rate seem to have been very little affected, while older children were no less susceptible than adults.

Among 47,000 cases of influenza treated by physicians in Bavaria in 1889, the various ages were as follows:

1 year	2–5	6–10	11–15	16–20	21–30
1.5 per cent.	5.4 per cent.	6.6 per cent.	7.2 per cent.	11.4 per cent.	22.2 per cent.
31–40	41–50	51–60	61–70	71–80	Above 80
19.3 per cent.	12.6 per cent.	7.7 per cent.	3.6 per cent.	2.0 per cent.	0.5 per cent

Leubuscher recorded that in Jena the proportion of cases in the individual age classes did not correspond with the figures reported from other localities. Children, and especially very young children, suffered relatively less than adults.

The following statistics of the 1889–90 incidence of influenza among school children in Cologne were collected by Lent:

	Attendance.	Ill of influenza.	
Class I—13 to 14 years of age	3,002	1,015	33.8 per cent.
Class II—11 to 12 years of age	5,737	1,835	31.9 per cent.
Class III—10 years of age	3,701	1,130	30.5 per cent.
Class IV— 9 years of age	3,590	930	25.9 per cent.
Class V— 8 years of age	2,929	822	28.0 per cent.
Class VI— 7 years of age	3,388	758	22.3 per cent.

These may be compared with figures for the public schools in the suburbs of Cologne:

	Attendance.	Ill of influenza.	
Class I—13 to 14 years of age	1,609	689	42.9 per cent.
Class II—11 to 12 years of age	2,885	1,094	37.9 per cent.
Class III—10 years of age	1,683	626	37.1 per cent.
Class IV— 9 years of age	1,758	552	31.4 per cent.
Class V— 8 years of age	1,771	502	28.2 per cent.
Class VI— 7 years of age	1,938	510	26.3 per cent.

The increase of disease incidence with age is apparent. Finkler's explanation for the higher incidence among the children of the suburbs, "that the children in the country had usually to walk a greater distance to school" does not appear to be complete.

Comby found that out of 3,411 school children in Lausanne 1,840 contracted influenza. This shows a relatively high incidence in children of school age in that city.

Concerning age distribution in 1889–90 Leichtenstern remarks that the greatest morbidity incidence was in school children, adolescents and young adults, especially the last. Nursing infants were attacked in considerably less degree than any of these other ages. Also in the higher ages those above sixty were attacked in lesser degree. The greatest morbidity frequently was between the ages of twenty and forty. Abbott concluded on the basis of estimates furnished him from various institutions and individuals in the State that people of all ages were attacked but the ratio of adults was greatest, of old people next, and of children and infants least.

Relationship of occupation to morbidity incidence.—Leichtenstern found that the only apparent influence of occupation on the incidence of influenza depended upon the liability to exposure in the various occupations. He remarks particularly on the large incidence of influenza among physicians. In contrast was the low incidence in lighthouse keepers. In 1889–90 among 415 dwellers on 51 lightships and 20 isolated lighthouses on the English coast only 8 persons developed influenza and these in four localities, and in every instance there was traceable direct communication from some other source. There is contradictory evidence as to whether individuals working out of doors are more apt to develop influenza. Certain statistics show that postmen and individuals working on railroads were attacked more frequently and earlier than others, while other statistics show that in railroads the office personnel was attacked earlier than individuals on the trains and those working on the tracks.

Abbott concluded that special occupations did not appear to have had a marked effect in modifying the severity of the epidemic. At

the Boston Post Office in 1889–90, of the indoor employees, 475 in number, 25 per cent. were attacked. Of the carriers, 450 in number, 11 per cent. were affected with the disease. But there were other reports of the same period which stated that the ratio of the persons employed at outdoor occupations who were attacked was greater than that of indoor occupation.

Finkler has discussed the influence of occupation at some length:

"When we compare the statistics of the last pandemic concerning the influence of vocation, we see in the first place that those first and chiefly were attacked whose occupation compelled them to remain in the open air. This was shown especially by Neidhardt, who studied the influenza epidemic in the Grand Duchy of Hesse. His conclusions, however, were disputed by others. Thus, the prejudicial influence of exposure to the open air was not supported by the statistics of railroad employees in Saxony. Of those who were employed in the outdoor service, 32 per cent. became ill; of those employed in office work, on the other hand, 40 per cent. The statistics of the local benefit societies in Plauen show that the percentage of the sick among farm hands and builders was not greater than that among the members of other benefit societies who worked indoors. In Schwarzenberg the laborers in the forest who were working in the open air all day were affected less than others, and there was no sickness whatever in some forest districts. Lancereaux, of Paris, states that most of the railroad employees who suffered from influenza were those engaged in office work and not those who worked in the open air. The preponderance of influenza patients among the factory hands may be seen from a table prepared by Ripperger:

A. In the open air.

Occupation.	Per cent. attacked.
Workmen and laborers of Niederbayern	7
Railway officials in Amberg	9
Peasants in Niederbayern	11.7
Workmen in the Salzach-Correction	20

B. In closed rooms.

Slag mills in St. Jugbert	15
Cotton mill in Bamberg	20
Cotton mill in Bayreuth	33
Sugar factory in Bayreuth	36
Aniline works in Ludwigshafen	38.8
Cotton mill in Zweibrücken	50
Tinware factory in Amberg	60
Factory in Schweinfurth	62
Gun factory in Amberg	70
Gold beaters in Stockach	80

"Many peculiar records of how individual classes of occupation have fared are obviously to be explained by the fact that the infection manifested its action in very different degrees. Thus, among the workmen on the Baltic ship-canal only those became ill who lived in the town of Rendsburg; those who had been housed in barracks outside of the city were not affected. Of the 438 lead workers of Rockhope, which is situated in a lonely valley in Durham, all remained perfectly free from the disease during the three epidemics of 1889–92.

"Some occupations are said to afford protection against influenza. Thus workmen in tanneries, chloride of lime, tar, cement, sulphuric acid, glass, and coke works, are said to have escaped the disease with extraordinary frequency.

"We shall be compelled perhaps to agree with Leichtenstern in his conclusion that occupation and social position only in so far exert an influence on the frequency of the disease as certain occupations in life lead to more or less contact with travellers.

"Very remarkable is the proportionately small number of soldiers affected, at least in the Prussian army, where, according to the official record, the epidemic from its beginning to its end attacked only 101.5 per thousand of the entire forces."

Comparison of morbidity by occupation necessarily includes so many variables and so many factors other than occupation that the results are decidedly unsatisfactory. An example is found in Jordan, Reed and Fink's report of the incidence among troops in the Student Army Training Camps in Chicago. They found a strikingly different attack rate in the various groups studied. In the Chicago Telephone Exchange they ranged from 30 to 270 per 1,000, although the working conditions in the various exchanges were not materially different. In the Student Army Training Corps at the University of Chicago the lowest was 39 and the highest 398 per 1,000. The higher rate group was particularly exposed to infection while the lower, although composed of men of similar ages, living under similar conditions, were guarded to a considerable extent against contact with beginning cases.

Woolley has made an interesting observation on the effect of occupation: "The disease was no respecter of persons except that it was more severe in those who were hard workers. Those who tried to 'buck the game' and 'stay with it' showed the highest mortality rates. So, the non-commissioned officers and the nurses suffered more severely than the commissioned officers and privates.

"The annual morbidity rate per 1,000 was as follows:

For commissioned officers	261
Non-commissioned officers	208
Nurses	416
White enlisted men	568
Black enlisted men	1,130

"The annual mortality rate per 1,000 was:

For commissioned officers	69
Non-commissioned officers	83
Nurses	77
White enlisted men	145
Black enlisted men	253

"The case mortalities were:

	Per cent.
For commissioned officers	26.8
Non-commissioned officers	40.0
Nurses	33.3
White enlisted men	26.0
Black enlisted men	22.5

"The above figures are for the period of five weeks from August 28th to October 1st, 1918, and cover the most active portion of the epidemic, but are obviously incomplete. They are given for purposes of comparison."

Woolley makes the observation that the organizations which spent most of the time in the open and which were therefore most exposed to the weather suffered least during the epidemic. This was particularly true in the Remount Depot.

In our work we have attempted to classify our population according to occupation along very broad lines.

"*Infant*" includes all individuals up to the age of two years. In these the exposure is limited by the fact that they are either relatively isolated at home, or when abroad, are still under relative isolation in a perambulator or under the eye of a nurse. There is relatively little commingling with the older age groups.

"*Child*" refers to all children up to the age of school years. There is relatively much greater commingling, particularly with other individuals of the same age.

"*School*" refers to all children and adolescents who were reported as attending school.

"*Home*" includes not only the housewife, the housekeeper, but also servants and invalids; all who in their daily routine spend the greater part of the time in the home.

"*Manual Indoors*" refers chiefly to laborers in factories and includes all manufacturing occupations in which the work is of a manual character no matter what the particular branch.

"*Manual Outdoors*" refers to such occupations as ditch diggers, street cleaners, conductors and motormen, longshoremen, trucksters and teamsters, telephone and telegraph linemen, etc.

"*Retail Sales Indoors*" refers to clerks in stores and all other individuals who, working indoors, come into about the same degree of contact with the public-at-large.

"*Retail Sales Outdoors*" includes sales agents, life insurance agents, traveling salesman, pedlers, newsboys, etc.

"*Office,*" officials, secretaries, stenographers, telephone operators, telegraph operators, etc.

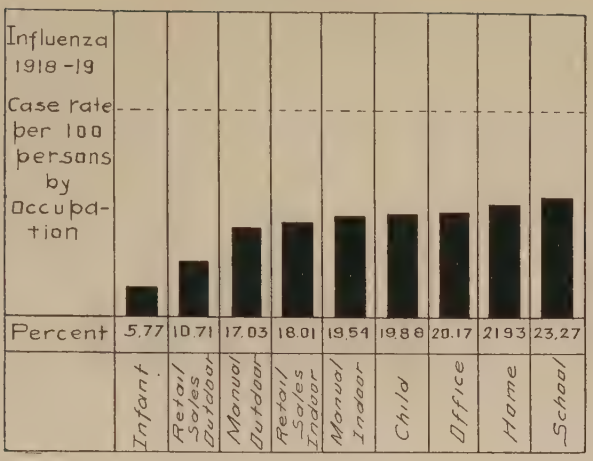
We have observed that in 1918 infants presented the lowest incidence and school children the highest. Occupations designated Home and Office were surprisingly high. Children also showed a high incidence, one out of every five developing the disease. The records show that manual labor, both indoors and outdoors, was associated with a higher incidence than less strenuous work, as retail sales, indoors and outdoors (Chart XXIII).

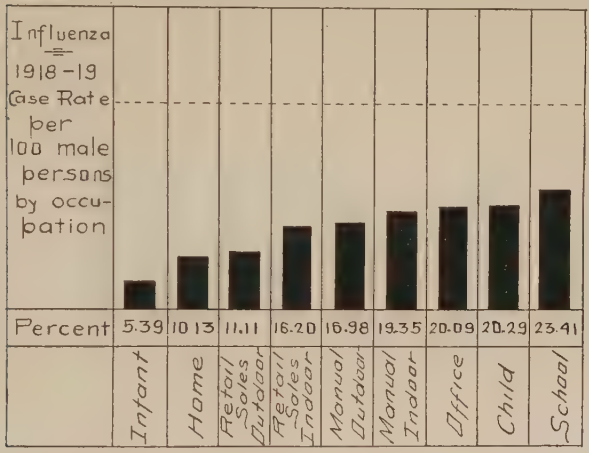
The attack rates in most of the occupations are so nearly the same as to lead to no certain conclusions. It would appear from our records that individuals working out of doors were less frequently attacked than those whose occupation kept them in doors. The groups at the two extremes of incidence correspond to what we should expect when considering opportunities for contract. The infant has least direct contact. His contact is only with one or a few individuals, the mother or the nurse. This group developed the disease in 5.8 per cent. The school child not only has the same degree of contact as do adults, but also in the tussle and scramble of play the contact becomes much closer. The factor of age plays a large part in the occupational distribution and the apparent occupational susceptibility is influenced by the age susceptibility.

When we consider the occupational incidence in the various districts we find that the only constant feature in the relatively small groups is the low incidence among infants (Chart XXIV).

The first fact gained from a study of the 1920 occupational case rate is that just as was the case in age incidence there is less variation between the highest and the lowest than in 1918–19. While in the first epidemic the highest occupational rate was five times the lowest, in the second it was only twice the lowest (Chart XXV). But at the

CHART XXIII.


Influenza 1918-19
Case rate per 100 persons by occupation
Percent
5.77
10.71
17.03
18.01
19.54
19.88
20.17
21.93
23.27
Infant
Retail Sales Outdoor
Manual Outdoor
Retail Sales Indoor
Manual Indoor
Child
Office
Home
School


Influenza
1918-19
Case Rate per 100 male persons by occupation
Percent
5.39
10.13
11.11
16.20
16.98
19.35
20.09
20.29
23.41
Infant
Home
Retail Sales Outdoor
Retail Sales Indoor
Manual Outdoor
Manual Indoor
Office
Child
School

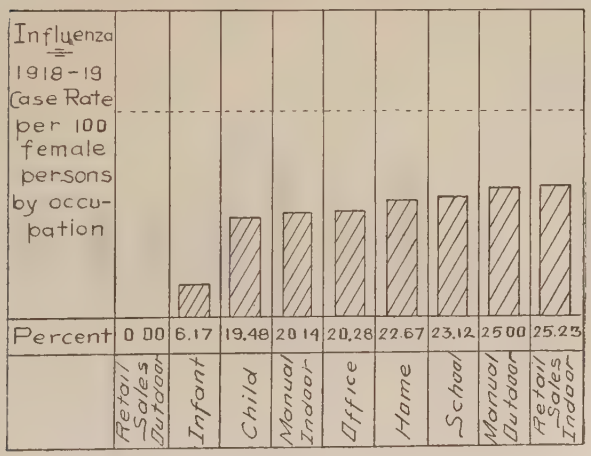

Influenza
1918-19
Case Rate per 100 female persons by occupation
Percent
0.00
6.17
19.48
20.14
20.28
22.67
23.12
25.00
25.23
Retail Sales Outdoor
Infant
Child
Manual Indoor
Office
Home
School
Manual Outdoor
Retail Sales Indoor

CHART XXIV.

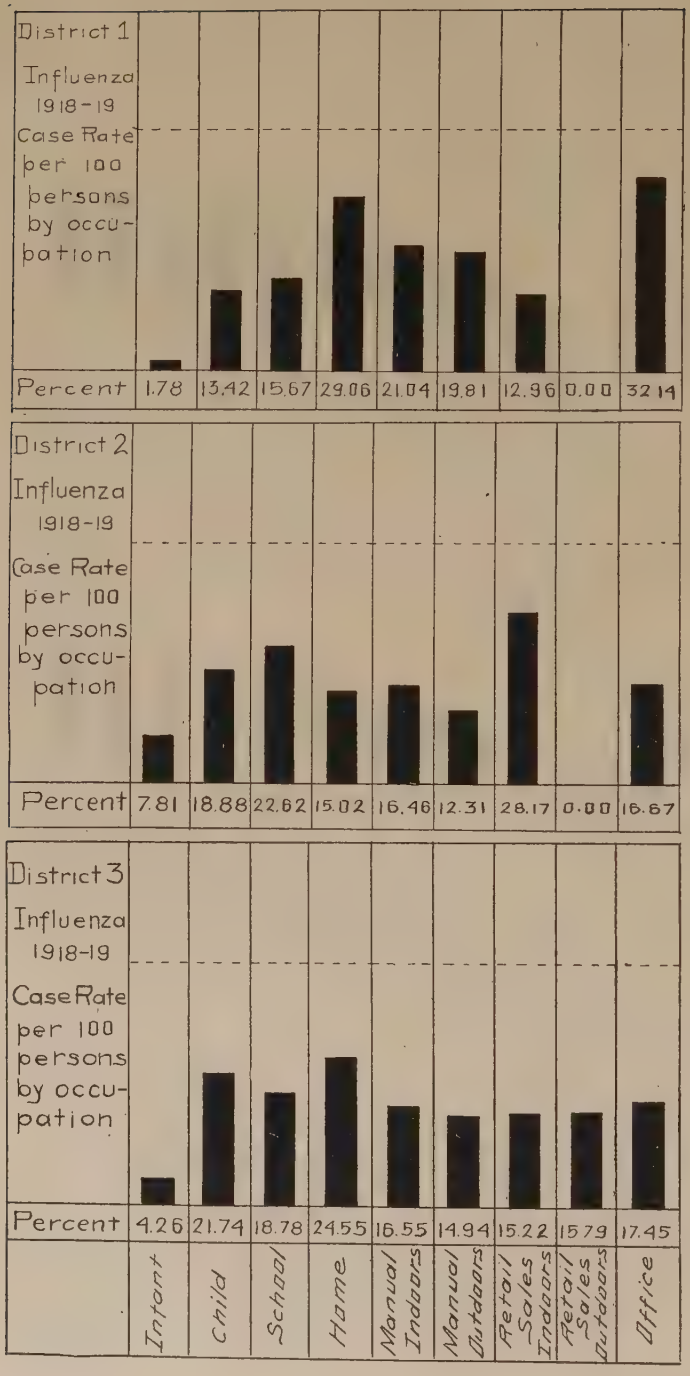

District 1
Influenza 1918-19
Case Rate per 100 persons by occupation
Percent
1.78
13.42
15.67
29.06
21.04
19.81
12.96
0.00
32.19
District 2
Influenza 1918-19
Case Rate per 100 persons by occupation
Percent
7.81
18.88
22.62
15.02
16.46
12.31
28.17
0.00
16.67
District 3
Influenza 1918-19
Case Rate per 100 persons by occupation
Percent
4.26
21.74
18.78
24.55
16.55
14.94
15.22
15.79
17.45
Infant
Child
School
Home
Manual Indoors
Manual Outdoors
Retail Sales Indoors
Retail Sales Outdoors
Office

CHART XXIV.—(*Cont.*)

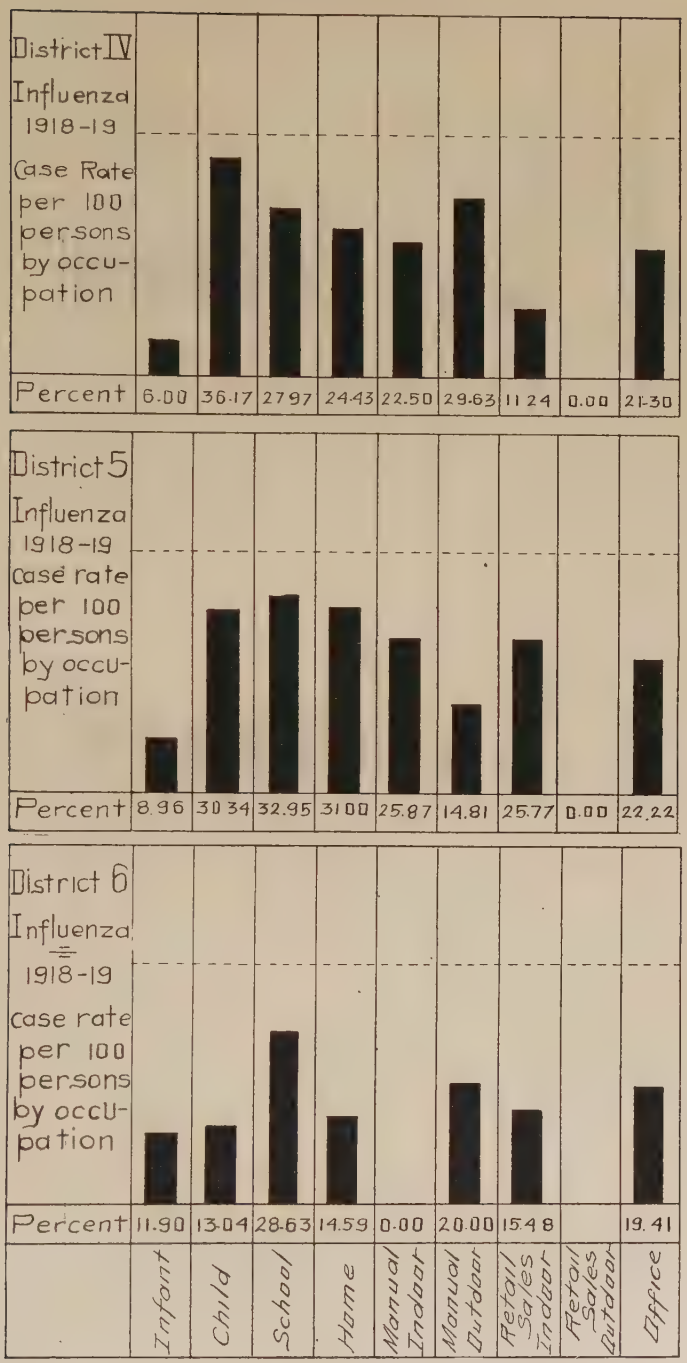
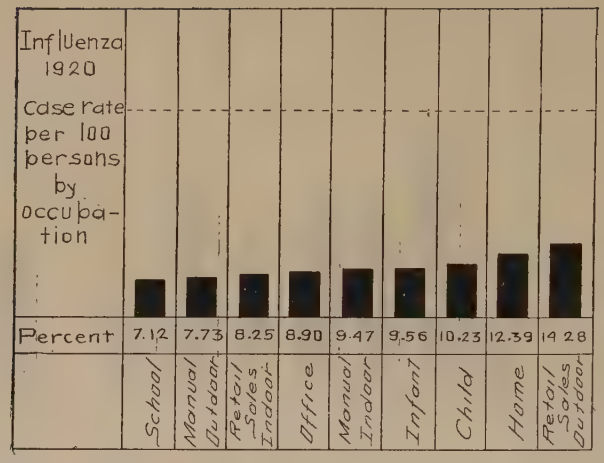
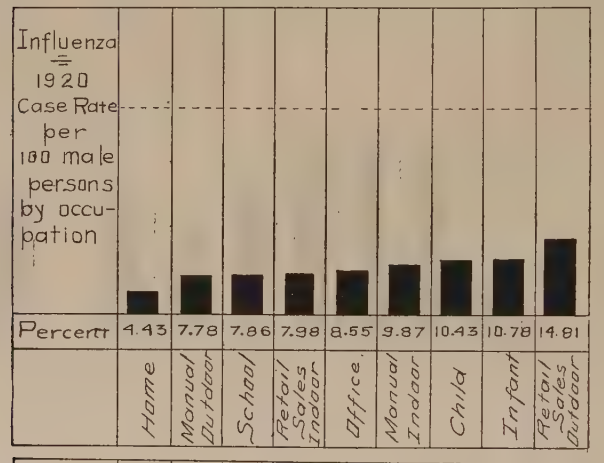


CHART XXV.


Influenza 1920
Case rate per 100 persons by occupation
Percent
7.12
7.73
8.25
8.90
9.47
9.56
10.23
12.39
14.28
School
Manual Outdoor
Retail Sales Indoor
Office
Manual Indoor
Infant
Child
Home
Retail Sales Outdoor


Influenza 1920
Case Rate per 100 male persons by occupation
Percent
4.43
7.78
7.86
7.98
8.55
9.87
10.43
10.78
14.81
Home
Manual Outdoor
School
Retail Sales Indoor
Office
Manual Indoor
Child
Infant
Retail Sales Outdoor

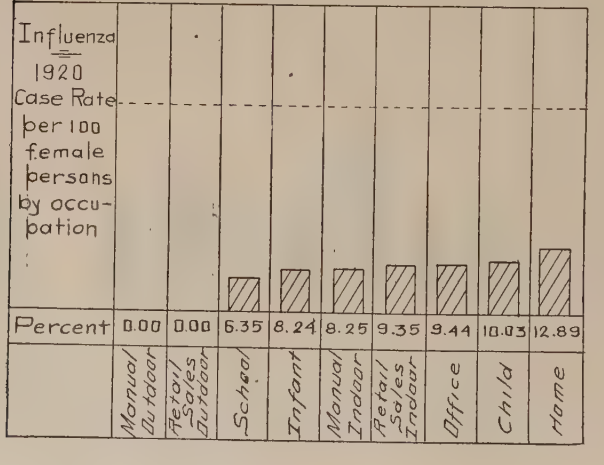
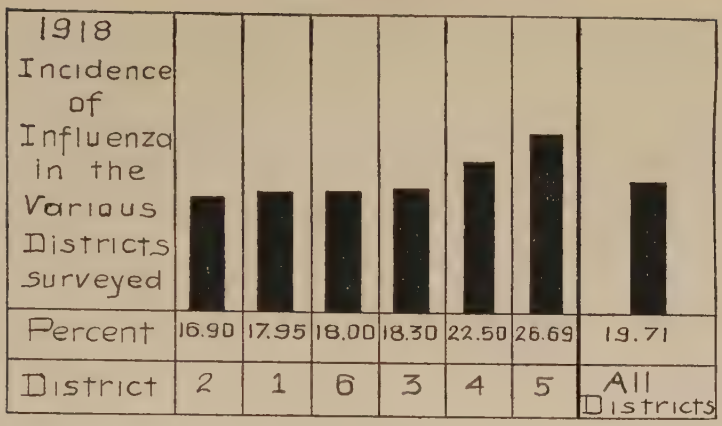
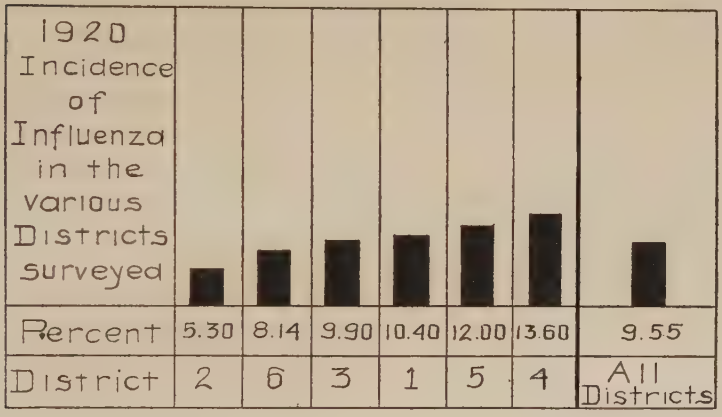
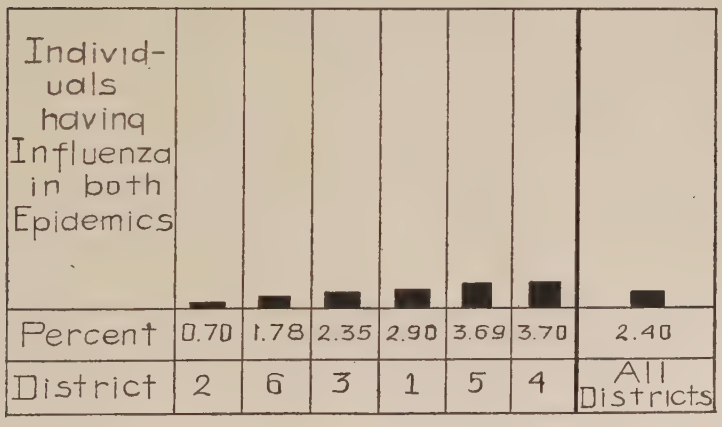
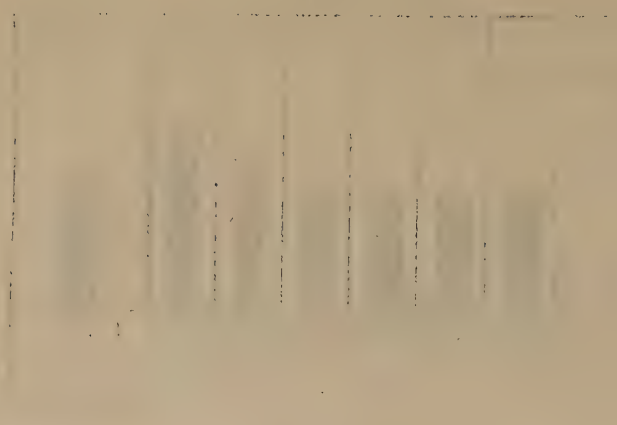

Influenza 1920
Case Rate per 100 female persons by occupation
Percent
0.00
0.00
6.35
8.24
8.25
9.35
9.44
10.03
12.89
Manual Outdoor
Retail Sales Outdoor
School
Infant
Manual Indoor
Retail Sales Indoor
Office
Child
Home

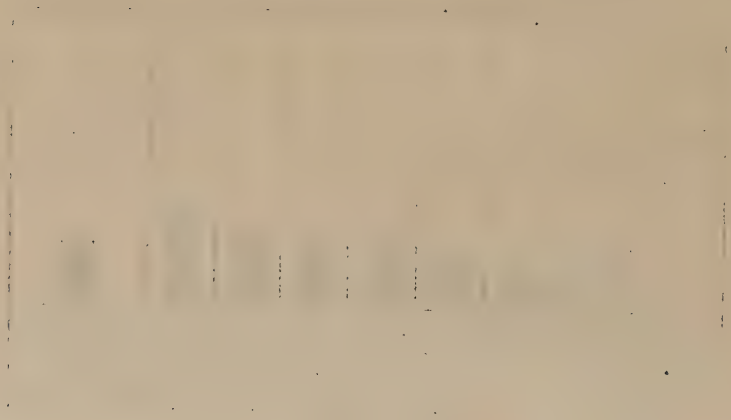
CHART XXVI.


1918
Incidence of Influenza in the Various Districts surveyed
Percent
16.90
17.95
18.00
18.30
22.50
26.69
19.71
District
2
1
6
3
4
5
All Districts


1920
Incidence of Influenza in the various Districts surveyed
Percent
5.30
8.14
9.90
10.40
12.00
13.60
9.55
District
2
6
3
1
5
4
All Districts


Individuals having Influenza in both Epidemics
Percent
0.70
1.78
2.35
2.90
3.69
3.70
2.40
District
2
6
3
1
5
4
All Districts





extremes of the two charts we see some tendency to an inversion of the order. In 1918–19 those occupied in "retail sales" outdoors showed a low incidence, while in 1920 they were the highest. So also, the incidence in the school group changed from highest in 1918 to lowest in 1920. The incidence in infants increased; that in the office workers decreased. No general conclusions are warranted from these results.

In comparing the sex incidence by age groups we have found that females as a rule showed a slightly greater incidence than males. That this is not due fundamentally to occupational differences is suggested by a comparison of the sex incidence in the two epidemics studied. In 1918 the distribution is practically the same in the two sexes in all occupations except "Home," "Manual Outdoors," "Retail Sales Indoors," "Retail Sales Outdoors" (Chart XXVI). In the first the number of males is so small and in the second and fourth the number of females is so small that these cannot justly be compared. The group, "Retail Sales," consists in 1918–19 of 69 males and 27 females, out of a total distribution in the population of 426 males and 107 females. This is the only occupation that showed a definite higher incidence among the females, and even here the number is too small for accuracy. In 1920 this difference has practically disappeared.

Effect of race stock.—Leichtenstern remarks in his monograph that the reported differences in influenza morbidity among different races, such for instance as European and other nationalities, doubtless are due to factors other than genetic racial differences, such as different modes of living, commerce, etc. The work of the last two years calls for a reconsideration of this idea.

Frost in his valuable work found that "in the seven localities with considerable colored population the incidence rates among the colored were uniformly lower than among the whites, the difference persisting after adjustment of the rate to a uniform basis of sex and age distribution. The extent of the difference varied, being relatively great in Baltimore, Augusta and Louisville, and very small in Little Rock. This relatively low incidence in the colored race is quite contrary to what would have been expected a priori, in view of the fact that the death rate from pneumonia and influenza is normally higher in the colored than in the white, and that the colored population lived generally under conditions presumably more favorable to the spread of contact infection."

Brewer, in his study of influenza in September, 1918, at Camp Humphreys, finds that the colored troops showed a decidedly lower rate than the white troops throughout the epidemic. He finds that

the incidence among colored troops was only 43 per cent. of that among whites. The difference between colored and white organizations was probably not due to difference in housing. Most of the colored troops were in tents and the white troops were all in barracks. But the 42d Company composed of negroes was housed in barracks under the same conditions as the white troops of other organizations and they had next to the lowest incidence of all organizations. Brewer concludes that the colored race when living under good hygienic conditions is not as susceptible to influenza as the white race under the same conditions. The age distribution was the same in both groups.

Armstrong concluded from figures based on reported cases of influenza that in the autumn of 1918 proportionately four times as much influenza and pneumonia was reported among the Italians as was reported for the rest of the Framingham community, made up largely of Irish or Irish-American stock. On the contrary, an examination of a large proportion of the population of that town showed a tuberculosis incidence among the Italian race stock of .48, in contrast to an incidence among the Irish of 4.85 per cent. and of 2.16 per cent. in the entire population. Armstrong contrasts the relative insusceptibility of Italian stock to tuberculosis, with the apparent marked susceptibility to acute disease of the respiratory tract, such as influenza and pneumonia; and the high susceptibility of the Irish to tuberculosis, with their low susceptibility to acute respiratory infection.

With regard to our work it is sufficient to state that the lowest incidence in both epidemics, as well as in recurrent cases, was in the Irish tenement districts. Both the Jewish and the Italian tenement districts were slightly higher in both epidemics (Charts XIX and XXI). The age distribution of the entire population of each of these three districts was about the same, so it does not appear that the slightly lower incidence among the Irish is due to a variation in the age distribution of the population.

The subject of race in relation to influenza will be discussed further under mortality.

Mortality.

According to Marchese, in 1387 at Forli in Italy, not a person escaped the disease, but only a few died. Gassar says that during the same epidemic in Germany the patients suffered four, or at most five, days with the most disagreeable catarrhal symptoms and delirium, but recovered, and only very few were removed by death.

Pasquier remarks concerning an epidemic in 1411 that an infinitude of individuals were attacked but that none died.

Concerning the epidemic of 1414 in France, Lobineau relates that the disease was fatal only for the aged. Mezeray also speaks of the high mortality of the old in this epidemic.

Regarding the pandemic of 1510, Thomas Short remarks that none died except some children. Mezeray, on the other hand, says that the disease had claimed many victims.

Pasquier and Valleriola both write of the epidemic of 1557, in France, as being distinctly mild in character. Children only who could not freely cough out the phlegm died. Coyttar speaks of the absence of death except in tuberculous patients.

In the pandemic of 1580 individual observers report enormous death rates. Thus, according to Schenkius, the disease killed 9,000 persons in Rome, while Madrid, Barcelona and other Spanish cities were said to have been nearly depopulated by the disease. This high mortality was, however, even at that time attributed by some physicians to the injudicious employment of venesection. Throughout the more recent history of pandemic influenza opinion seems to have been nearly unanimous that blood letting has had very bad results in the outcome of influenza cases. Remarks to this effect have been made by the contempories of nearly every epidemic since 1580.

According to Rayger and others during the epidemic of 1675, nobody died of the disease itself with the exception of debilitated persons, although it spared neither the weak nor the strong.

Concerning the epidemic of 1688, Thomas Short writes for England that though not one of fifteen escaped it, yet not one of a thousand that had it died.

In 1712, Slevogt writes that in Germany "Fear soon vanished when it was seen that although it had spread all over the city, it left the sick with equal rapidity."

Finkler remarks, concerning 1729–30, that, "The great mortality which attended the epidemic in England and Italy seems somewhat remarkable. Thus Hahn states that in London in the month of September one thousand persons died each week, and in Mayence forty persons daily. Most likely, however, other diseases which were present at the same time added their quota to the mortality, especially as the disease in other places, for example in Germany, ran a benign course."

Perkins, Huxham, Pelargus, Carl and others, concerning the epidemic of 1732–33, all testify that the disease was of very low fatality.

In 1742 the epidemic was evidenced by an enormous morbidity but the disease was not dangerous as a general rule although Huxham occasionally speaks of the virulent character of the disease in England,

and Cohansen says that in January, 1743, over 8,000 persons died from influenza in Rome and 5,000 in Mayence.

We have the testimony of Robert Whytt, for 1758, and that of Razoux and Saillant and Ehrman for 1762, as to the low mortality of the epidemic for those years.

According to Heberden the same was true for 1775, while Webster tells us for 1780 that the disease was not dangerous but its effects were seen the following year in the increased number of cases of phthisis.

Finkler remarks concerning the epidemic of 1802, "The mortality in this epidemic was small, only the abuse of venesection brought many to the grave. Thus, so many farmers are said to have died in Russia from it that venesection was forbidden by an imperial ukase. Jonas says that many patients were bled either on the advice of a simple village barber or by their own wish, and most of them died. In Prussia also bleeding was declared detrimental by the Government."

He continues regarding 1836–37, that, "In London there died, during the week ending January 24, 1837, a total of 871 persons, and among these deaths there were 295 from disease of the respiratory organs; during the week ending January 31st, out of a total of 860 deaths there were 309 from diseases of the respiratory organs."

Watson, in describing the epidemic of 1847, discusses the mortality:

"The absolute mortality has been enormous; yet the relative mortality has been small. You will hear people comparing the ravages of the influenza with those of the cholera, and inferring that the latter is the less dangerous complaint of the two; but this is plainly a great misapprehension. Less dangerous to the community at large (in this country at least) it certainly has been; but infinitely more dangerous to the individuals attacked by it. More persons have died of the influenza in the present year than died of the cholera when it raged in 1832; but then a vastly greater number have been affected with the one disease than with the other. I suppose that nearly one-half of those who were seized with the cholera perished; while but a very small fraction, indeed, not more probably than two per cent. of those who suffered influenza have sunk under it."

Leichtenstern remarks on the very low mortality of 1889–90. In Munich 0.6 per cent. died; in Rostock 0.8 per cent.; in Leipzig 0.5 per cent.; in fifteen Swiss cities 0.1 per cent.; in Karlsruhe 0.075 per cent.; in Mecklenburg-Schwerin 1.2 per cent. This does not, however, include the numerous deaths from complications, as from pneumonia, and does not express the true mortality.

Newsholme gives the following table for mortality from influenza,

bronchitis and pneumonia, in England and Wales during the epidemic years and the years immediately preceding them. The figures express annual death rate per million of population. The highest rate was reached in 1891. The table does not include deaths registered as from other diseases, but due directly or indirectly to influenza. Respiratory diseases in general show a greatly increased death rate in years in which influenza is epidemic. Such is also true to some extent with diseases of the nervous and the circulatory systems.

Death rate per million of population from	Non-epidemic years.			Epidemic years.		
	1887	1888	1889	1890	1891	1892
Influenza	3	3	2	157	574	533
Bronchitis	2,117	2,041	1,957	2,333	2,593	2,266
Pneumonia	1,113	1,093	1,022	1,404	1,471	1,250

In a report by the United States Public Health Service early in 1919 the death rates from all causes in twelve large cities of this country were compared for 1889–90 and for 1918–19. It was found that while considerable irregularity in the curves was evident, the curves of the two epidemics manifested on the whole quite a striking similarity for the same cities considered individually and for the group as a whole. The death rate rose to a much higher point during the autumn wave of the 1918 epidemic than in the epidemic of 1889–90 in nine out of the twelve cities. During both epidemics the rate was relatively low in St. Louis, Milwaukee and Minneapolis. The mortality in all of these cities was 26.7 in 1889, as against 35.2 for 1918. In the peak week the rate rose to 55.6 in 1918 as against 35.4 in 1889.

The influenza deaths in Massachusetts in the year 1890 during a period of fifty days were estimated by Abbott to have been 2,500. In 1918 Jordan estimates the mortality for the same state to have been six times as great. The population of the state had not doubled in the interval. The highest mortality from influenza in Massachusetts during the 1889–93 epidemic occurred in January, 1892, during which month the total deaths amounted to 6,309 which was greater by 2,246 than the mean monthly mortality of the year, and greater by more than 1,000 than the mortality of any month in the ten year period 1883–92.

A comprehensive comparison of the damage done by influenza in 1918 with the deaths from other plagues has been made by Vaughan and Palmer.

"The pandemic of 1918, when compared with that of 1889–90 is estimated to have caused *six times as many deaths.*

"During the four autumn months of 1918, 338,343 cases of influenza were reported to the Surgeon General. This means that in the camps of this country *one out of every four men had influenza.*

"The combination between influenza and pneumonia during the fall of 1918 seems to have been closer and more destructive than in any previous pandemic. During the autumn season there were reported to the Surgeon General 61,691 cases of pneumonia. This means that *one out of every twenty-four men encamped in this country had pneumonia.*

"During the same period 22,186 men were reported to have died from the combined effects of influenza and pneumonia. This means that among the troops in this country *one out of every sixty-seven died.*

"This fatality has been unparallelled in recent times. The influenza epidemic of 1918 ranks well up with the epidemics famous in history. Epidemiologists have regarded the dissemination of cholera from the Broad Street Well in London as a catastrophe. The typhoid epidemic of Plymouth, Pa., of 1885, is another illustration of the damage that can be done by epidemic disease once let loose. Yet the accompanying table shows that the fatality from influenza and pneumonia at Camp Sherman was greater than either of these. Compared with epidemics for which we have fairly accurate statistics the death rate at Camp Sherman in the fall of 1918 is surpassed only by that of plague in London in 1665 and that of yellow fever in Philadelphia in 1793.

"The plague killed 14 per cent. of London's population in seven months' time. Yellow fever destroyed 10 per cent. of the population of Philadelphia in four months. In seven weeks influenza and pneumonia killed 3.1 per cent. of the strength at Camp Sherman. If we consider the time factor, these three instances are not unlike in their lethality. The plague killed 2 per cent. of the population in a month, yellow fever 2.5 per cent. and influenza and pneumonia 1.9 per cent.

"In four months typhoid fever killed 1.5 per cent. of the soldiers encamped in this country during the war with Spain. Influenza and pneumonia killed 1.4 per cent. of the soldiers in our camps in 1918 and it also covered a period of four months."

The Bureau of the Census has made the following report concerning influenza deaths in the United States:

"In forty-six American cities, having a combined population of only a little more than one-fifth the total for the country, the mortality resulting from the influenza epidemic during the nine weeks

period ended November 9th was nearly double that in the A. E. F. from the time the first contingent landed in France until the cessation of hostilities."

The mortality, even as the morbidity, has varied in different localities and at different periods. The low morbidity and mortality in the spring of 1918 has been frequently mentioned. Among the Esquimaux in Alaska the death toll was terrific. Whole villages of Esquimaux lost their entire adult population. It has been estimated that in British India the death roll totalled 5,000,000. "The central, northern and western portions of India were the worst sufferers. The hospitals in the Punjab were choked so that it was impossible to move the dead quickly enough to make room for the dying. The streets and lanes of the cities were littered with dead and dying people. The postal and telegraph services were completely disorganized; the train service continued, but at all principal stations dead and dying people were being removed from the trains. The burning ghats and burial grounds were literally swamped with corpses, while an even greater number awaited removal. The depleted medical service, itself sorely stricken by the epidemic, was incapable of dealing with more than a minute fraction of the sickness requiring attention. Nearly every household was lamenting death, and everywhere terror and confusion reigned. No part of the Punjab escaped."

The Bureau of the Census estimates that 445,000 deaths from the epidemic of influenza occurred in the United States in the period between September 1st and December 31st, 1918. There is no doubt but that the total death toll for that epidemic exceeded 500,000 individuals.

According to Winslow and Rogers, the two highest annual death rates on record in Connecticut are both rates of 19.4 per 1,000 and these two rates are for the influenza epidemic years of 1892 and 1918. In the earlier of these two the normal general death rate was several points higher than it is today, so that the effect of the recent epidemic was much more serious than was that of its predecessor. For a single month the death toll of October, 1918, was absolutely unprecedented in Connecticut. They estimate that the epidemic between September, 1918, and January, 1919, cost the State 5.5 lives per 1,000 population, or, in all, 7,700 lives.

In the United States Army there was a total of 688,869 admissions for influenza. The total deaths ascribed to the disease are 39,731, which gives a rate of 15.64 per 1,000 for the acute respiratory diseases out of the total disease death rate of 18.81 for the year. In 1915 the per cent. of deaths from this group of infections was under 18 per cent.

of the total from all diseases. During the last four months of 1918, 11,670 deaths from influenza and pneumonia occurred in the American Expeditionary Forces in France. There were approximately 1,600,000 officers and men in the United States and an equal number in France.

Carnwath gives the following comparison of the number of deaths in London and in certain American cities from influenza and all forms of pneumonia during the eight weeks of the 1918–19 epidemic.

Deaths in London and in American cities.

	Number of deaths.	Rate eight weeks per 100,000 of population.
London	13,744	341
New York	20,681	360
Chicago	8,785	343
Philadelphia	12,806	749
Boston	4,211	548

The cause of death in the vast majority of cases is some form of pneumonia. In fact it has been questioned whether influenza uncomplicated can cause a fatal issue. Post-influenzal meningitis has been the cause of death in an appreciable number of cases. More remotely the disease has caused many deaths by hastening the fatal outcome of what were otherwise subacute or chronic conditions of the respiratory, cardiovascular, or renal systems.

Vaughan and Palmer record that, "The pandemic of influenza in 1918 seems to have been more closely associated with the pneumonias than appears in any previous pandemic. From the reports as sent to the Surgeon General's Office, it appears that uncomplicated influenza was not by any means a fatal disease and that the high death rate was due to the pneumonias which followed. Pneumonia is a serious disease at all times. Recent records for the United States Army show that the case mortality rate for this disease has been as follows during the different periods of the last two years:

	Per cent.
The year 1917	11.2
6 winter months, 1917–18	23.1
5 summer months, 1918	18.8
4 autumn months, 1918 (Influenza period)	34.4

"It is not strange that once pneumonia has secured a foothold in patients already weakened by influenza their chances of recovery were lessened."

Woolley reports that for the troops stationed at Camp Devens, Mass. there were no fatalities from uncomplicated influenza. In every fatal

case but two a diagnosis of pneumonia was made, and in these two cases pure cultures of pneumococcus were obtained from the blood after death, so it appears that they were cases of pneumococcus septicemia. Up to October 29, 1918, 19 per cent. of the total number of influenza cases reported developed pneumonia and of these there was a case mortality of 27.9 per cent. The mortality rate among the influenza cases was 5.4 per cent.

At Camp Humphreys, Virginia, 16 per cent. of the camp was attacked by the disease; 28 per cent. of influenza cases had pneumonia; 10 per cent. of influenza cases died; and 35 per cent. of pneumonia cases died. One and six tenths per cent. of the population of the camp died from influenza. The camp had an average strength of 26,600 individuals. Fifty-two per cent. of the entire number of cases occurred during the peak week which ended October 4th.

Between September 21st and October 18th, 1918, 9,037 patients were admitted to the Base Hospital at Camp Grant. This represented about one-fourth of the strength of the camp. Of these 26 per cent. developed pneumonia and 43 per cent. of the pneumonia cases died. Death occurred to about 11 per cent. of the total admissions.

The death rate at Camps Devens, Sherman and Grant were among the highest of all of the camps in this country. The annual death rate from all causes per 1,000 for the four last months of 1918 were 132 for Camp Cody, 123 for Syracuse, 116 for Camp Sherman, 102 for Camp Beauregard, 97.3 for Camp Grant, 75.0 for Camp Dix, 67.0 for Camp Devens. These seven camps stood out high above the majority. By far the majority, 28 camps, had an annual rate between 61.9 and 25.5 per 1,000. Only four camps recorded lower rates than the latter figure.

The Municipal Statistics of Paris showed that during the first half of October, 1918, the average weekly mortality was from two to three times that of non-epidemic years. The returns for the Departments of France also showed a mortality three times above the average for previous years, though not uniformly so. In the Departments the mortality from influenza did not exceed 10 per cent. and in many cases it was below 5 per cent. On the other hand cases admitted to hospital, which consisted of the worst forms of the disease, showed a mortality varying between 12 and 30 per cent. Returns received from Italy were similar. The disease in that country was especially severe in the northern part and in the provinces bordering on Switzerland. Marcus, of Stockholm, reported in September, 1918, that the epidemic in Sweden was running a very severe course, more than 1,000 deaths

having occurred up to the time of his report. According to Weber, 2,770 deaths occurred in Berlin during October, 1918, from influenza and pneumonia alone. In Vienna there died from influenza between September 1st and October 19th, 1918, 3,125 persons. The deaths in Vienna from influenza and pneumonia normally total 40 to 50 per week. At the highest point of the epidemic this number had increased to 1,468. Böhm estimates the total influenza incidence in Vienna as 180,000 cases, with a probable mortality around 1.7 per cent. Dunlop estimates that the total number of influenza deaths in Scotland in the winter of 1918–19 may be assessed at 20,000.

A. Giltay has compared the epidemics of 1890 and 1900 with that of 1918 as regards mortality, in Amsterdam. He has studied figures for seven consecutive weeks in each of the three periods under observation and found that the maximum figures for mortality were 61.5 in 1890, 41.2 in 1900, and 52.7 in 1918, but if these figures are compared with the average mortality for the year it is found that the increase of mortality as the result of influenza alone is 39.3 for 1890, 24.5 for 1900, and 40.3 for 1918. Thus the present epidemic is more severe than that of 1890.

Many reported mortality figures are without value because they are either death rates in selected groups such as those in a hospital, or, because the report does not state the status of the individual. Thus, Hoppe-Seyler stated at a meeting of the Kiel Medical Society that of 577 cases treated in the Municipal Hospital, nearly all of which were severe, 28.9 per cent. died. This was reduced to 18 per cent. after deducting the cases admitted in a moribund condition. Again, Rondopoulos reports that the October wave in Greece resulted in a mortality of from 15 to 24 per cent. in different localities.

Just as current vital statistics are of little value in determining the morbidity rate, so also they cannot be relied upon in obtaining fatality percentages. In organizations such as the Army, where all cases are reported, we may get some idea of the fatality rate. The deaths in the United States Army have already been discussed. Marcus, of Stockholm, reports that the military records showed that there had been 34,000 cases in the Swedish Army, with 444 deaths, making a mortality of 1.3 per cent. in that Army.

House surveys also give a fair idea of the mortality. Winslow and Rogers conclude that the fatality rate was as a rule somewhere between two and four deaths per 100 cases, the lower being more likely to be correct. Reeks found in his house census that there had been 3.9 deaths per 100 cases in the autumn of 1918. Carnwath reports that

Dr. Niven, in his census, discovered that out of 1,108 cases in the spring and autumn of 1918 there were but 15 deaths, which would give a fatality rate of 1.3 per 100 cases.

Frost has found from his large survey that the ratio of deaths to total cases of influenza varied in the localities surveyed from 3.1 per cent. in New London as a high point to 2.8 per cent. in San Antonio, Texas. There was some apparent relationship between fatality rate and geographic distribution, the higher rates being in San Francisco on the Pacific Coast, and in the localities studied on the north half of the Atlantic Seaboard, and the lower rates being in the central and southern states. The fatality rate on the Pacific Coast was 2.33, on the Atlantic Seaboard 2.05, and in the last district 1.08 per cent.

Our own figures correspond very closely with those of Frost. Among the 10,000 living individuals surveyed in 1920 there were 1,970 cases of influenza in 1918. Add to this the 50 deaths for 1918, which were not included in the 10,000 living individuals, which makes a total incidence of 2,021. This case fatality rate of 2.47 per 100, corresponds closely to Frost's rate for the North Atlantic Seaboard.

The relative mildness of the 1920 recurrence is indicated in the lower case fatality rate. Fourteen out of 955 cases died, giving a rate of 1.47 per 100 cases.

Mortality by sex.—There is not a uniformity of opinion as to which sex suffered the higher fatality rate during the 1918–19 spread. Winslow and Rogers found for Connecticut a distinctly heavier mortality among males for the last four months of 1918, 58 per cent. of the influenza-pneumonia deaths being among this sex. They believe that this is probably due to a greater exposure to the original infection.

Fränkel and Dublin point out that in a study of 70,729 policy holders of the Industrial Department of the Metropolitan Life Insurance Company in the period from October 1, 1918, to June, 1919, the death rates for males and females were practically the same for both white and colored individuals.

The excess of males over females among the whites is only three per cent., and there was no excess among colored. In contrast, the respiratory diseases, including influenza-pneumonia, under normal conditions, show a higher mortality incidence among males than among females. In the seven year period from 1911 to 1917 the mortality rate showed an excess of 18 per cent. males over females, among whites, and of 30 per cent. among colored. This would seem to indicate that the effect of the epidemic was not much, if any, greater on males than on females, and suggests that the excess mortality caused

by the epidemic did not operate on the sexes as the normal mortality from influenza-pneumonia had in previous years.

Dunlop finds that in a study of 10,797 deaths registered in Scotland up until the end of December, 1918, 52.44 per cent. were females and 47.56 were males. These were for deaths reported as due only to influenza. Apert and Flipo found a decided predominance among the female deaths in Paris. In both of these observations the absence from the civilian population of male inhabitants of military age obscured correct comparative statistics.

Once again, Frost gives the most comprehensive discussion of the subject. He found, as we have stated, that the influenza case incidence in persons over fifteen years of age was higher in females than in males, and that in persons under fifteen the relative incidence as between males and females is variable, but with very slight excess in males for the localities studied, combined. On the other hand, the case fatality, the per cent. of influenza cases dying, under fifteen years of age, was higher in females than in males. Over sixty years of age it was considerably higher among the females, but between the ages of fifteen and sixty the general tendency was to a much higher case fatality among the males. The difference was greatest between the ages of 20 and 40. The case fatality between the ages of 15 and 45 in the group of southern and central states was in decided contrast to that in the Northern Atlantic and Pacific groups, the case fatality in the former being remarkably low in both sections and slightly higher in females than in males. He suggests that in the south and middle west where the epidemic was generally milder in respect to mortality than in the northeast and far west, the essential difference was not in case incidence, but in case fatality, especially in persons from 15 to 45 years of age, and in the relatively low case fatality among young male adults. Frost makes the important point that the relative mortality is determined more accurately by case fatality than by case incidence, and that without a full and exact knowledge of the variations in case fatality, statistics of mortality are by no means translatable to terms of relative morbidity. The fact that certain cities showed, as described by Pearl, relatively high mortality rates, does not give conclusive evidence that the morbidity was higher in these cities than elsewhere. The lower influenza case fatality in females from 15 to 60 years of age appears to be accounted for in part at least; first, by a decreased incidence of pneumonia as compared with the males; and, second, by a lower fatality in those cases which did develop pneumonia.

The relatively small number of fatalities in our own records do not

warrant a classification by age groups. We found that for all ages in 1918 7.9 per cent. of females developed pneumonia as contrasted with 6.8 per cent. males. This does not include those who died. In 1920, 1.87 per cent. of the male cases died, while only 0.37 per cent. of the females died. Five and fifteen-hundredths per cent. of all male cases developed pneumonia and recovered, and 3.56 of the females did likewise. In 1920 a higher proportion of males than females developed pneumonia, and likewise a higher proportion died.

Relationship of age.—Leichtenstern has summarized the results for the epidemic of thirty years ago, in saying that the death rate for children under one year was little disturbed by the influenza epidemic; that there was very little increase in mortality in the other ages of childhood; that the higher age periods showed the greatest relative mortality for the disease. On the contrary, the records for England and for Switzerland showed during those periods a higher death rate in children up to five years of age.

	Percentages.	
Ages.	1847–8	1890
1– 5	10.5	5.2
5–20	13.1	4.3
20–40	3.8	4.7
40–60	18.5	36.2
60–80	16.9	22.4
Above 80	8.6	2.5

Giltay has compared the age mortality in Amsterdam in 1890, 1900 and 1918 as shown in the following table:

	Under one year.	1–4	5–13	14–19	20–49	50–64	Over 64	Total.
1890	8.4	8.1	2.3	3.0	30.7	19.3	28.1	100
1900	9.7	8.8	1.6	3.2	17.6	18.3	40.8	100
1918	3.0	13.0	8.7	8.3	51.9	8.7	6.4	100

Evans has studied the records for the city of Chicago in the epidemic of the year 1890, and found that the number of deaths was highest among persons from 20 to 40 years of age. The greater increase above the expected was in deaths of persons over 60 years of age. Children of school age seemed to enjoy some relative immunity, as shown in the mortality reports.

This latter age grouping for 30 years ago corresponds with those of 1918. Frost found that the death rate per 1,000 was notably high in children under one year of age, in adults from 20 to 40, and in

persons over 60. The case fatality from pneumonia in his series tended to be fairly constant, around 30 per cent., except in San Antonio, Texas, where it was only 18.5 per cent. Case fatality was also higher in the following age groups: Under one year, 20 to 40, and over sixty.

This age distribution was probably the same in all countries. Filtzos, describing the epidemic in Greece, said that the ages that suffered most and had the most fatal cases were between 20 and 45. In Spain in May and June of 1918 the mortality was much lower among children and the aged than it was among the adults, especially between 20 and 39 years of age. The disease appeared fatal almost exclusively in these ages. In Vienna, 29.5 per cent. of all the fatal cases were between the ages of 20 and 30. Hoppe-Seyler stated that the ages of most of the cases were between 20 and 40 and the majority between 30 and 40, but that the mortality was highest among the older patients.

Dunlop found that in Scotland the most frequent ages at death were between 25 and 35, 25.28 per cent. of the total being between these two ages. 53.85 per cent. of the total deaths were between 15 and 45 years. The highest age group death rates occurred in age groups 75 and over, and 25 to 35, the former being 7.87 per 1,000, and the latter 7.12. High rates also occurred in age groups under one, and 65 to 75, the former being 6.49, and the latter 5.33. The lowest age group death rates were found in the groups which included children of school age, 5 to 15, being 2.20 per cent., and the age group 10 to 15, being 1.80 per cent. Dunlop has apparently only included those cases in which influenza was diagnosed as the cause of death, and has omitted all in which the diagnosis was bronchitis or pneumonia.

The Bureau of the Census has issued a report based on the mortality in Indiana, Kansas and Philadelphia, for the period September 1st to December 31st, 1918. It shows that the highest rate occurred in the age period from 30 to 34 years, with the period from 25 to 29 second. Of all the deaths tabulated more than half occurred between the period of 20 to 40, although this age group represents only 33 per cent. of the total population concerned.

Age mortality has been studied thoroughly by Winslow and Rogers in Connecticut:

"The four last months of 1917 show a normal age distribution with one quarter of all deaths occurring under five years of age, one quarter between 5 and 40 years, and one-half over 40 years, the proportion of the infant deaths decreasing and the proportion of deaths in old age increasing as one passes from the season of intestinal disturbances to

the season of respiratory diseases. In 1918 the distribution of deaths from all causes is strikingly different. Instead of less than a quarter of all deaths occurring between the ages of 5 and 40 years, this period included 49 per cent. of all deaths in 1918; and the two decades between 20 and 40 included 40 per cent. of all deaths (as against only 14 per cent. in 1917).

"Considering influenza and pneumonia alone, these two decades included 56 per cent. of the deaths, while only nine per cent. occurred at ages over 49. The decade between 20 and 29 was most severely affected, including 30 per cent. of all deaths, while the decade between 30 and 39 was a close second with 26 per cent. An even higher incidence occurred at ages under five years, as has been brought out in other investigations, since this age period contributed 16 per cent. of all the influenza-pneumonia deaths. The proportion of deaths from all causes in infancy did not rise even to normal, but with the enormous rise in total deaths the maintenance of a nearly normal ratio, of course, means a heavy influenza mortality."

Jordan observes in his analysis a low pneumonia incidence among the pupils of elementary and high schools. There were no deaths in 188 cases.

Wollstein and Goldbloom report that in a series of 36 children with influenza and bronchopneumonia at the Babies Hospital in the City of New York, 66.6 per cent. died. Achard and his co-workers review a similar series of 32 infants in Paris with influenza. Eight of the 32 died. In both of these studies we are dealing with selected groups of hospital cases and the mortality rates are of little value for this type of study.

Fränkel and Dublin in a study of 70,729 deaths from influenza-pneumonia among the policyholders of the Industrial Department of the Metropolitan Life Insurance Company, find that during the normal period between 1911 and 1917, influenza-pneumonia attacked primarily the first age period of life, ages one to four years, and the period of late middle life and old age. The rates are normally minimal between 5 and 30 years. In the last quarter of 1918, on the other hand, the highest rate among the whites is in the period of early adult life, between the ages of 25 and 34. There appear three modal points instead of the two at the extremes. They find that the excess over normal was most marked in infancy and early childhood, and particularly in early adult life, culminating between the ages of 25 and 34. The period of old age shows no significant *excess* during the period of the epidemic.

If the deaths among the white males of the age period of active adult life had continued throughout the whole year as they did during the last quarter of 1918, approximately four per cent. of the population of that age would have died.

Fränkel and Dublin are of the opinion that this change in the age incidence of influenza mortality between epidemic and endemic periods suggests strongly that the two diseases are different; that endemic influenza is not the same disease as epidemic influenza. Or perhaps they should say more correctly that the diseases occurring in interepidemic times which are reported to them as deaths due to influenza-pneumonia are not the same as the epidemic influenza. They draw similar conclusions from the different manner in which the white and black races are affected during the interepidemic and epidemic periods, from so-called influenza-pneumonia. We have seen from Frost's results that it is hazardous to compare mortality rates of different localities and different times with the idea of comparing the disease, influenza, itself.

The ages showing highest mortality in the autumn of 1918 appear to have been essentially the same as those which predominated thirty years ago. There appears to be nothing in the age distribution that could be explained by an immunity persisting over from the epidemic of 1889–93. The age group 30 to 40 has almost universally a higher mortality than the groups below 20, which would by this theory be non-immune and would be expected to have a higher rate. The drop in rate is nearer the age group of 40 than 30. The presence of smaller or larger influenza epidemics in the course of the thirty years would further complicate such an hypothesis.

Relationship to occupation.—Dublin found in a study of 4,700 miners that the death rate was unusually high from influenza in these individuals for the last quarter of 1918. In fact in the age period 45 to 65 the rate among bituminous coal miners is close to four times as high as among all occupied males. The annual death rate per thousand for all ages among the former is 50.1; among all industrial white males, 22.3. The increase is apparent in all age groups from 15 to 65 inclusive. These results are based on the records of the Metropolitan Life Insurance Company.

Density of population. Rural and urban environment.—There have been few reports which have like the above described clearly variations due apparently only to occupational differences. Some attention has been paid to a comparison of the rural incidence with that in large cities. Although other factors play a part here, we may consider

this under the general subject of occupation. Statistics for the fall of 1918 from the Netherlands show that with the exception of men over 80 years of age the mortality was remarkably increased for both sexes in communities of less than 20,000 inhabitants.

Winslow and Rogers have studied the variations in the urban and rural incidence and find that in Connecticut with the single exception of Tolland County, in which the small towns were severely hit, the rates were in every case *higher* in the large communities. In New Haven County, for instance, among nine towns which were purely agricultural, the combined death rate from influenza and pneumonia for the three months of September to November, inclusive, was 9.2 on an annual basis. For six towns in the same county in which there were manufacturing plants the corresponding rate was 15.6. In Litchfield County the twelve purely agricultural towns had a combined rate of 6.5, whereas among eleven partly manufacturing towns the rate was 18.3. This was true for other counties. The figures quoted are for influenza-pneumonia rates only up to December 1st, but study of the records during the early months of 1919 did not show any change in the figures. The rates for the entire state for January, 1919, was 19.8, and that for the towns under 5,000, only 17.5.

These observations differ somewhat from those reported by Pearl, who studied 39 large cities of the United States in an attempt to find a correlation between the explosiveness of the influenza outbreak and the density of population. He concluded that there was no such correlation. Pearl, however, was dealing with cities which were all sufficiently large to offer practically complete opportunities for contact infection, and the two reports, therefore, cannot be justly compared. Winslow and Rogers suggest as possible causes for lessened incidence in rural communities either diminished opportunities for contact infection or differences in age distribution and racial composition of the different populations.

Let us consider in greater detail the fate of both rural and urban individuals who had been recently drafted into the military forces of this country. Almost universally the raw recruit was found more susceptible to disease than was the seasoned soldier. A report by Lieutenant W. D. Wallis from Camp Lee "shows that while those who had been in the service less than one month constituted only 9.19 per cent. of the total strength, they furnished 30.11 per cent. of the total deaths from influenza and consequent pneumonia. Furthermore, it is shown that while those who had been in the service from one to three months constituted 45.18 per cent. of the camp, they

furnished 46.24 per cent. of deaths. On the other hand, those who had been in the service more than three months constituted 46.63 per cent. of the population and furnished only 23.69 per cent. of deaths.

Lieutenant Wallis says: "These figures show a much greater percentage of deaths for the first month in camp than the corresponding proportion of the population would warrant; while in the period of three months or more of service the percentage is less than half of that of the camp population having this length of service. The only approach to a correspondence is in the period from one to three months where the respective percentages differ but little The increase in length of service is accompanied by a progressive decrease in the percentage of deaths from 30.11 per cent. to 27.41 per cent. to 18.87 per cent., although only 9.19 per cent. of the population in the camp falls within the class of less than one month's service.

"The incidence of mortality is in the first month's service more than three-fold the percentage of the number of men; and in the period of three months or more of service is scarcely more than half of the percentage of the number of men of the camp in that group.

"The fact that the case mortality is higher among those who came from rural homes than among those who came from cities seems to hold even after three month's of service, or more."

Vaughan and Palmer found that the case fatality at Camp Dix among those who came from cities with a population of 10,000 or more was 10.8; while among those who came from more rural homes the rate was 15.8, although the average service of both groups was the same.

The Camp Surgeon of Camp Grant concluded from his records that the new recruit is more susceptible to influenza and is more apt to succumb than is the man who has been trained and is accustomed to Army life.

Wooley reports data collected from four Infantry organizations at Camp Devens comprising 15,502 men. Of 9,559 men who had been in camp less than five months, 3,575 or 37.5 per cent. developed influenza, whereas of 5,943 men who had seen more than five months service in the army, 1,033 or 17.5 per cent. developed the disease. He concludes that the large number of recruits in the camp certainly was a factor in increasing the disease incidence. It should be remarked that Camp Devens appears not to have had any influenza epidemic in the spring of 1918.

It is to be regretted that we have not several reports dealing with the same subject from camps where the disease was definitely recog-

nized in the spring. Fortunately we have one such. Opie and his co-workers have observed that the epidemic at Camp Funston, which occurred between March 4th and March 29th, 1918, and which attacked 1,127 out of a total of 29,000 men, involved chiefly the organizations which had been at Camp Funston during six months or more. At that time it seems to have infected all susceptible individuals, and to have spent itself. Subsequent waves of influenza, four in number, and coming at a little less than one month intervals, occurred when newly drafted men were brought into the camp in April and May. In these latter cases the disease affected the men newly arrived in camp.

At Camp Funston, at least, the higher incidence in the raw recruit appears to be explained in part by a relative immunity of those who had been in camp a month or more, existing as a result of an earlier prevalence of the disease. More abundant evidence would, however, be necessary before we could deny a diminution of natural immunity in the recruits, caused by the exposure, overwork, fatigue, and change of daily routine. As V. C. Vaughan has remarked: "It appears that natural immunity gives way before exposure, overwork and fatigue, as was demonstrated years ago by Pasteur in his experiments on birds with anthrax. Likewise, it is possible for human beings to have their resistance lowered by exposure to unaccustomed environment, so that although naturally immune, the standard of immunity is reduced to the point where the influenza virus gains admittance and overcomes the lowered resistance."

Race stock and mortality.—The relationship of morbidity to race stock has already been considered and should be borne in mind in a discussion of mortality by race.

We have seen how the natives of India suffered unusually from the influenza, the total deaths being estimated at over 5,000,000 individuals. A preliminary report from the Department of the Interior on the mortality from influenza among American Indians showed that during the six months period from October 1, 1918, to March 31, 1919, over two per cent. of the Indian population died of influenza. The mortality among Indians in the Mountain States, especially in Colorado, Utah and New Mexico, was very high. For the Indian population as a whole the annual mortality rate from influenza alone during the six months period was according to the U. S. Public Health Reports 41.2 per 1,000, which is above that for the larger cities in the United States during the same epidemic period.

In both of the above races we cannot say that it was not factors other than race, particularly living conditions, that resulted in the high mortality.

Winslow and Rogers found in Connecticut that the proportion of influenza-pneumonia deaths was lower than would be expected among persons of native Irish, English and German stock, but higher than would be expected among Russian, Austrian, Canadian and Polish stock, and enormously high among Italians. They suggest that this marked difference in racial incidence may be very largely due to the differences in age distribution of the various race-stocks, the races showing the highest ratios being those which have arrived more recently in the country and which are made up more largely of young adults at the ages which suffer most severely from influenza. They further refer to the work done by Armstrong in Framingham, and state that their results tend to confirm his conclusions in regard to the Italians, as do the figures presented by Greenberg from the records of the Visiting Nurse Association of New Haven. "It appears that Italy suffered very severely from the influenza epidemic in Europe, and Dublin has shown that the normal pneumonia rate of this race is a very high one."

We have rather more abundant comparison of the white and black races in this country. Frost found in his extensive survey that the case fatality was generally higher among the colored than among the white population. A similar observation was made by Howard and Love, who found that the case mortality for influenza and its complications in the United States and in the American Expeditionary Forces, in 1918, was for colored troops 4.3 per cent. and for white troops 3.3.

These two series of observations are of great importance, for they are about all we have describing case fatality rate. The majority of other reports describe mortality rate only, and are therefore not complete.

The death rate in the Army was higher among colored troops, but the incidence of influenza, the rate per 1,000, was lower for the colored race. "Considering only the southern states, the nativity rate for influenza for the white was 247.11 and for the colored, 154.58. For lobar pneumonia it was 10.77 for the white and 28.31 for the colored; for bronchopneumonia and unclassified pneumonia 7.26 for the whites and 11.43 for the colored. It seems probable that the negro is less susceptible to influenza than the southern whites, but that he is much more susceptible to pneumonic infections, either primary or secondary."

Fränkel and Dublin have studied the racial distribution of 70,729 deaths among policy holders of the Industrial Department of the Metropolitan Life Insurance Company, particularly with respect to incidence among white and black. Normally the mortality from

respiratory diseases is higher among colored persons than among whites. In the seven year period from 1911 to 1917, influenza-pneumonia death rates showed an excess of 72 per cent. colored males over white males and of 56 per cent. colored females over white females. During the period of the epidemic the situation was reversed. The whites suffered from higher rates than the colored. While the rate among white males during the period, October to December, 1918, was nearly fifteen times as great as during the period 1911 to 1917; that of colored males was only seven times as great as the rate during the same seven year period. White females during the height of the epidemic showed a rate more than sixteen times as high as the normal, while colored females experienced a rate only nine times as high. After the first of January, 1919, the excess rate returned slowly to the normal figures. These facts are based on death rate only.

Any comparison of race morbidity or mortality, to be of value, must be based on observations of individuals living in the same climate, in the same domestic environment, and in similar age distribution. It is practically impossible to discover groups living under such conditions. Howard and Love, perhaps, approached more nearly to such an ideal in studying the white and black races in the Army, but even in the military forces many factors are at play. Thus, the death rate among enlisted men was highest among the American troops in the United States (12.02); second in Europe (6.07); third in Panama (1.09); fourth in Hawaii (0.55); fifth in the Philippine Islands (0.14). By race it was highest for the colored troops (12.69); second for the white (8.83); third for the Porto Ricans (7.80); fourth for the Filippinos (2.84); and fifth for the Hawaiians (1.72). The authors point out that while the native troops had higher admission rates than the whites, the death rates were lower, which illustrates the point that the death rate for this type of disease is lower in the summer and in the tropics.

SECTION IV.

An Intensive Study of the Spread of Influenza in Small Groups of Closely Associated Individuals.

We have been discussing the disease under consideration chiefly from the viewpoint of the statistician. The statistician, possessing a wealth of information of a general nature, and from all parts of the world, and armed with fascinating complex mathematical instruments, is able to dissect the information at his disposal, and to reconstruct

therefrom both facts and apparent facts of absorbing interest. To him we are indebted for the bulk of our knowledge of the distribution and spread of the influenza through metropolies, through countries, and through continents.

Like the aviator flying over enemy territory he acquires a breadth of vision and a general perspective which is to a great extent denied to those remaining on the ground. But also like the aviator, from the very fact of his high position he loses the ability to recognize detail. The small sub-divisions in the enemy lines are slightly blurred and he can distinguish the front line trenches in which most of the action is occurring no more clearly than the reserve and support trenches. An Army depending entirely upon its aeroplane reconaissance would find itself helpless in combatting the enemy. The aeroplane is useful, yes, it could not be dispensed with, but never an opportunity is lost for scouting parties to explore the enemy front lines; it is these latter who bring back information as to the local strength and distribution of the enemy, as to what particular divisions are in action, as to the strength of the entrenchments, the enemy distribution within the trenches, and finally what is most important, information as to the weak points in the enemy's lines, places at which we may concentrate our attack with the hope of driving the enemy from its stronghold. Occasionally a raiding party will return with a prisoner. He will be examined thoroughly and may yield some valuable information. All such prisoners are not dressed alike. We recognize that some belong to one regiment and some to another. After we have extracted what information we can from the prisoner he is incarcerated, if we may extend our metaphor, in a test tube, and there he remains for future reference. We do not believe that these individual private soldiers are the cause of the war, but we do know that they are doing their share of the killing—that they are doing most of the killing.

It is characteristic of human enthusiasm and hopefulness that each raiding party prays that it may bring back with it a general officer, a field marshall, the one who is chiefly responsible for the enemy offensive. In our own little battle with our invisible host we have long since discovered that field marshalls here as elsewhere are difficult to discover by raiding parties. But the raids are and should be made just the same. They almost invariably bring back some new item of information, and it is the experience of many wars that even though the commanding general be never captured, repeated small or large attacks following preliminary reconaissance, if diligently and valiantly prosecuted under good leadership may win the war.

In studying the life and habits of the influenza virus and its army of secondary invaders, and the results thereof in small groups composed of individuals as the unit, instead of large groups with communities as a unit, we will be able to discover a certain number of additional facts, some of which may have considerable value.

In the study by the author of six selected districts in Boston a special study was made of the occurrence and manner of spread of the influenza in the household or family as a unit. The 10,000 individuals canvassed were distributed through 2,117 families. Of these two thousand odd families, 45.44 per cent. were visited with one or more cases of the disease in the 1918–19 epidemic, and 27.25 per cent. in the winter of 1920. Of these, 14.31 per cent. had cases in both epidemics. In either one or both of the two epidemics under consideration, 58.38 per cent. of all families had influenza (see Table III).

TABLE III.

Per cent. of families invaded by influenza.

Boston District No.	1918–19.	1920.	1918–19 and 1920.	Total.
1	49.59	32.79	20.05	62.33
2	36.04	17.36	7.25	46.15
3	45.89	26.43	14.71	57.61
4	48.48	32.20	14.39	66.29
5	52.48	34.11	19.53	67.06
6	43.16	24.21	11.23	56.14
All Districts	45.44	27.25	14.31	58.38

Explanatory note: 45.44 per cent. of all families were invaded in 1918.
27.25 per cent. of all families were invaded in 1920.
14.31 per cent. of all families were invaded in both epidemics.
58.38 per cent. of all families were invaded in one or the other or both.
41.62 per cent. of all families remained free from influenza throughout both epidemics.

In this discussion of family incidence, as in our work on the incidence among individuals, the question naturally arises as to the reliability of our information and the accuracy of our results. We have shown the close correspondence between our own results and those of Frost, done on a vastly larger number of individuals. The information for families was obtained from the same sources and from the same individuals. The thoroughness with which the inspectors did their work is indicated by the fact that in addition to the 2,117 families on which we base our results, only the records of 194 families

have been discarded for various reasons. In discarding the family records we also discarded the individual records and such are, therefore, for individuals above our total of 10,000. One hundred and fifty-four of these were for families whose homes were in the districts surveyed, but who were not at home at the time of the first survey. These were omitted during the second survey, irrespective of whether individuals were at home. In this group are also included a few in which children were at home, but were unable to give reliable information. Fifteen of the 194 families gave insufficient information, and 25 refused to co-operate. The small number in this last group speaks well for the efficiency and methods of the inspectors. All families accepted for tabulation co-operated to the best of their ability, and we believe that the records are as accurate as this type of work may be made.

Dr. Niven, in the work referred to by Carnwath, made an inquiry covering 1,021 houses, with a population of 4,721. Five hundred and three households or almost exactly one-half, were invaded in either the summer 1918, or the autumn-winter 1918 epidemic. This proportion of families is quite similar to our own, but it must be pointed out that Niven was not studying the same two epidemics that we are discussing. Two hundred and sixty-six of his total households, or 26.05 per cent. were invaded in the autumn epidemic.

Previous to the present time the author has been unable to find records of investigators having used this method of studying influenza to any appreciable extent. Certainly there has been nothing done on the subject previous to the last pandemic. Since then Frost has studied, as indicated in his report, family incidence to the extent of determining the relationship to overcrowding and to economic status, and Niven has studied family incidence with special reference to immunity.

Thomas Sydenham, speaking of the epidemic of 1675, says that: "No one escaped them whatever might be his age or temperament, and they ran through whole families at once."

According to Waldschmidt, during the epidemic of 1712, in Kiel, ten or more persons were frequently taken ill in one house.

In 1732, Huxam tells us that, "not a house was free from it, the beggar's hut and the nobleman's palace were alike subject to its attack, scarce a person escaping either in town or country, old and young, strong and infirm, shared the same fate."

Metzger says that the influenza was so universal in March, 1782, that in very many houses all of the inmates were attacked. On the

other hand, Mertens did not believe the influenza a contagion during the same epidemic for the reason that according to his observations now only one, and again all, of the members of a family, were stricken.

In 1833, in Königsberg, according to Hufeland, parents, children, and servants were frequently smitten with the disease at the same time, so that strange help had to be obtained for the family.

Parkes taught that, "Persons in overcrowded habitations have, particularly in some epidemics, especially suffered, and several instances are on record of a large school or a barrack for soldiers being first attacked, and of the disease prevailing there for some days before it began to prevail in the town around. Sometimes, on the other hand, schools and prisons have escaped. A low, damp, ill-ventilated and unhealthy situation appears to predispose to it, and in some instances, in hospital patients, it has assumed a malignant character. In other cases again, hospital patients have escaped; for example, the old people in the Salpêtrière in 1837, when the younger attendants were attacked."

Effect of overcrowding.—The family or household forms a social unit in which human intercourse is very close, and in which the opportunities for contact infection either direct or indirect are manifold. In addition to all of the opportunities which each individual has for contracting the disease outside of the family every case in the family exposes every other member many times during the day. One of the first questions arising in a study of the disease in the family is, therefore, whether the size of the family in and of itself exerts any predisposing influence on the total incidence in any one family. Are large families more likely to have a greater percentage of cases than small families? We have endeavored to answer this question by grouping together all families containing only one individual, all of those with two, three, four, etc., and determining the percentage of individuals contracting influenza in each of the groups. The standard for comparison is the percentage of the total 10,000 who contracted the disease in either year, or in both. 19.71 per cent. of all persons canvassed contracted influenza in 1918–19. Reference to Table IV shows that of persons living in families of one, 17.95 per cent. developed the disease; of those in families of two, 18.46 per cent.; in families of three, 19.96 per cent.; in families of four, 20.10 per cent.; and in families of from five to seven, between 22 and 23 per cent. Families of over seven all showed lower, but varying incidence of the disease. As is seen by the table, they comprise only a small number of families.

TABLE IV.

The incidence of influenza in families of different sizes.

(Influence of size of family).

No. of individuals in family.	No. of such families.	Total No. of individuals included in all such families.	Number of these individuals who developed influenza.					
			1918.		1920.		Total.	
			No.	Per cent.	No.	Per cent.	No.	Per cent.
1	39	39	7	17.95	3	7.69	10	24.42
2	260	520	96	18.46	55	10.58	151	29.04
3	359	1077	215	19.96	128	11.88	343	31.85
4	396	1584	319	20.10	169	10.67	488	30.81
5	375	1875	423	22.56	203	10.83	626	33.39
6	264	1584	361	22.79	151	9.53	512	32.32
7	179	1253	279	22.27	109	8.70	388	30.96
8	103	824	156	18.93	55	6.67	211	25.61
9	57	513	85	16.57	21	4.09	106	20.66
10	28	280	40	14.14	26	9.29	66	23.57
11	15	165	10	6.06	7	4.24	17	10.30
12	4	48	0	0.0	5	10.42	5	10.42
13	2	26	5	19.23	3	11.54	8	30.77
14	1	14	0	0.0	0	0.0	0	0.0

In 1920, 9.55 per cent. of the entire canvassed population contracted the disease. The table shows that 7.69 per cent. of all individuals in families of one contracted influenza, and between 10 and 12 per cent. in families of from two to five individuals. Above the family of five the incidence rates again are lower and varying within wide limits. The last column shows the percentage of individuals by size of family contracting the disease in either or both epidemics.

The average size of all families was 4.7 individuals.

If we consider only those family groups having over 1,000 individuals as being sufficiently large to be representative, we may conclude that families of from three to seven individuals show no progressive increase in influenza incidence with increase in size of the family. But all the available evidence indicates that other things being equal, the age incidence is a very important factor. Its influence will be felt in the subject under consideration, and it will modify the results. Thus, families of one or two are almost invariably adults; families of three are very frequently made up of two adults and a child or infant, while families of from five to seven will be more likely to have a high proportion of young adults—the age period more seriously affected.

The next question arising is whether those families, large or small, which are living in crowded circumstances, are more likely to develop

the disease. Arbitrary standards must be chosen as indices of crowding. We have chosen two in order that they may check each other. The first is based upon the number of individuals sleeping in a bedroom. Families are classified as follows: Maximum sleeping in a single bedroom, 1; maximum sleeping in a single bedroom, 2; maximum per bedroom, 3, 4, etc.

The second standard of crowding is based upon the ratio of the number of individuals in the family and the number of rooms occupied. One person living in one room is not crowded; two in two rooms, three in three rooms, four in four rooms, eight in eight rooms, twelve in twelve rooms, are not crowded. Two people living in one room four in two rooms, six in three rooms, twelve in six rooms, are decidedly more crowded. On the contrary, one individual in two rooms, two in four, three in six, four in eight, five in ten, etc. have an unusual amount of room.

The ratios $\frac{P}{R}$ are then throughout, $\frac{1}{1}$, $\frac{2}{1}$, $\frac{1}{2}$. These are used as dividing lines. All families with ratios higher than $\frac{2}{1}$ are classed as very crowded. Families with ratios above $\frac{1}{1}$ up to and including $\frac{2}{1}$ are classed as crowded. Families with ratios above $\frac{1}{2}$ up to and including $\frac{1}{1}$ are classed as roomy, and those with ratio of $\frac{1}{2}$ or lower are classified as very roomy.

Classifying all families in all six districts according to these last four degrees of crowding, we find, as is shown by Table V, that there is a progressive increase in the proportion of families with one or more cases of the disease, with increase in the extent of crowding.

According to the standard first described we find as is shown in Table VI that families with three, four and five individuals sleeping in a single room show a progressive increase of incidence over those families with but one or two per bedroom. This again is shown best in the total for all families, but is borne out in a study of each district. These statistics are however of little value for the study of the effect of overcrowding, because crowded families are usually large families. With an influenza incidence of 20 per cent. we would theoretically expect every family of five or larger to have one or more cases. This would amount to 100 per cent. infected families and such a state would not only influence, but dominate the statistics regarding overcrowding.

An objection will be raised, and justly so, that we have up to this point been studying influenza in families irrespective of how many cases there are in each family. Until now the family with one case was classified exactly the same as the family with eight cases. In the

TABLE V.

Effect of crowding on development of influenza in families.

(A higher proportion of crowded households than roomy are invaded).
(Standard used: ratio of number individuals to number rooms).

Living conditions.	No. of such families.	Proportion of these families visited by influenza.							
		In 1918–19.		In 1920.		In both epidemics (Recurrent).		Total families invaded.	
		No.	Per cent.	No.	Per cent.	No.	Per cent.	No.	Per cent.
District I.									
V. Cr.	53	30	56.61	15	28.31	12	22.64	31	58.49
Cr.	195	107	54.87	59	30.26	43	22.05	123	63.08
R.	79	36	45.57	24	30.38	18	22.78	42	53.16
V. R.	16	7	43.75	1	6.6	0	0.0	8	50.00
District II.									
V. Cr.	4	1	25.00	1	25.00	1	25.00	1	25.00
Cr.	137	70	51.09	31	22.63	2	8.76	89	64.96
R.	208	70	33.65	39	18.75	7	8.17	92	44.23
V. R.	103	20	19.42	7	6.80	2	1.94	25	24.27
District III.									
V. Cr.	13	9	69.23	2	15.38	1	7.69	10	76.92
Cr.	213	99	46.48	65	30.52	40	18.78	124	58.22
R.	143	62	43.36	35	24.48	15	10.49	82	57.34
V. R.	21	8	27.59	2	6.89	2	6.89	8	38.09
District IV.									
V. Cr.	0	0	.....	0	.....	0	.....	0	.....
Cr.	27	18	66.67	8	29.63	5	18.52	21	77.77
R.	137	72	52.55	50	36.49	21	15.33	101	73.72
V. R.	95	38	40.00	27	28.42	12	12.63	53	55.79
District V.									
V. Cr.	6	2	33.33	4	66.67	2	33.33	4	66.67
Cr.	110	67	60.91	37	33.64	25	22.73	79	71.82
R.	209	104	49.76	70	33.49	38	18.18	146	69.86
V. R.	14	3	21.42	3	21.42	0	.....	6	42.84
District VI.									
V. Cr.	0	0	.....	0	.....	0	.....	0	.....
Cr.	2	1	50.00	0	0.0	0	0.0	1	50.00
R.	92	57	61.96	23	25.00	14	15.22	66	71.74
V. R.	189	65	34.39	46	24.34	19	10.05	92	48.68

Living conditions.	No. of families.	No. 1918.	Per cent. 1918.	No. 1920.	Per cent. 1920.	No. both.	Per cent. both.	Total	Per cent.
Very crowded	80	43	53.75	25	31.25	18	22.50	50	62.50
Crowded	693	372	53.68	201	29.00	126	18.18	447	64.50
Roomy	865	394	45.55	244	28.21	125	14.45	513	59.31
Very Roomy	443	143	32.28	87	19.64	36	8.13	194	43.79
All	Total	1918	Per cent.	1920	Per cent.	Both	Per cent.	Total	Per cent.
	2081	952	45.75	557	26.77	305	14.66	1204	57.86

TABLE VI.

Effect of crowding.

(Standard used: maximum number sleeping in one bed room.)

Maximum No. sleeping per room.	No. of such families.	Proportion of these families with cases of influenza.							
		In 1918–19.		In 1920.		In both epidemics.		Total families invaded.	
		No.	Per cent.	No.	Per cent.	No.	Per cent.	No.	Per cent.
District I.									
1	16	6	37.50	4	25.00	3	18.75	7	93.75
2	93	52	55.91	31	33.33	20	21.51	63	67.74
3	145	65	44.83	47	32.41	27	18.62	85	58.62
4	79	43	54.43	25	31.65	17	21.52	51	64.56
5	24	11	45.83	11	45.83	6	25.00	16	66.67
6	10	3	30.00	3	30.00	1	10.00	5	50.00
District II.									
1	90	15	16.67	7	7.77	2	2.22	20	22.22
2	211	68	32.23	36	17.06	14	6.64	90	42.65
3	115	59	51.30	23	20.00	10	8.69	72	66.61
4	33	20	60.60	11	33.33	6	18.18	25	75.76
5	3	1	33.33	2	66.67	1	33.33	2	66.67
6	0	0	.....	0	.....	0	.....	0	
District III.									
1	26	10	38.46	3	11.54	2	7.69	11	42.31
2	179	73	40.78	47	26.26	23	12.85	97	54.19
3	145	72	49.66	37	25.52	23	15.86	86	59.31
4	39	20	51.28	15	38.46	8	20.51	27	69.23
5	8	5	62.50	2	25.00	1	12.50	6	75.00
6	0	0	.....	0	.....	0	.....	0	
District IV.									
1	53	15	28.30	15	28.30	6	11.32	24	45.28
2	165	80	48.48	56	33.94	22	13.33	114	69.09
3	42	29	69.05	15	35.71	10	23.81	34	80.95
4	5	4	8.00	0	0.0	0	0.0	4	80.00
5	0	0	.....	0	0.0	0	.....	0	
6	0	0	.....	0	.....	0	.....	0	
District V.									
1	23	8	34.77	6	26.08	1	4.35	13	56.52
2	156	70	44.37	48	30.77	24	15.38	94	60.26
3	130	81	62.31	44	33.84	27	20.77	98	75.38
4	27	18	66.66	14	51.85	12	44.44	20	74.07
5	6	3	50.00	4	66.67	3	50.00	4	66.67
6	1	0	0.00	0	0.00	0	0.00	0	0.00
District VI.									
1	120	42	35.00	24	20.00	10	8.33	56	46.67
2	146	77	52.74	34	23.29	22	15.07	89	60.96
3	10	5	50.00	5	50.00	1	10.00	6	60.00
4	0	0	.....	0	.....	0	.....	0	
5	0	0	.....	0	.....	0	.....	0	
6	0	0	.....	0	.....	0	.....	0	
Total									
1	328	96	29.27	59	17.99	24	7.32	131	39.94
2	450	420	44.21	252	26.53	125	13.16	547	57.57
3	587	311	52.98	171	29.13	98	16.69	381	64.91
4	183	105	57.38	65	35.52	43	23.50	127	69.39
5	41	20	48.78	19	46.34	11	26.83	28	68.29
6	11	3	27.27	3	27.27	1	9.09	5	45.45

following classification we have taken first all families with a maximum of one sleeping in one room, and sub-divided these into families with no influenza, those with one case, two cases, etc. We have likewise classified families with maxima from two to six per bedroom. For the sake of brevity we will consider only the last column of Table VII, influenza incidence among the individuals of the various classes of families for both epidemics. Study of the table will show a correspondence in the other columns. Solitary cases were more numerous in families with but one or two per bedroom (27 per cent.) and less frequent in families with three, four and five per bedroom, (23 per cent., 18 per cent., and 20 per cent., respectively). The families of six per bedroom form such a small group that here again they should not be considered. Multiple cases become progressively more numerous as the number of individuals per bedroom increases (14 per cent. in families of one per bedroom, 29 per cent. in two per bedroom, 41 per cent. in three, 51 to 52 per cent. in four, and 45 per cent. in five). Fifty-eight per cent. of families with a maximum of one per bedroom, 43 per cent. with two per bedroom, 35 per cent. with three, 31 per cent. with four and 35 per cent. with five had no influenza at all.

But here again, the fact that crowded families are usually large families interferes with drawing any conclusions. A family with four per bed room would generally be larger than one with two per bed room.

Frost observed that, considering the ratio of incidence in total white populations irrespective of housing as 100, and after adjusting all groups to a uniform sex and age distribution, the ratio where there were more than 1.5 rooms per person was 77, from 1 to 1.5 rooms per person the ratio was 94, and for individuals averaging less than one room per person it was 117. *The attack rate showed a consistent increase as the number of rooms per person decreased.*

Woolley observed, "Housing, if one includes in the term overcrowding, has surely been an important factor in spreading the epidemic. Whether it has had any appreciable effect upon the incidence of complications is a question. The epidemic has certainly gone faster and was over sooner because of the crowding; the hospital was filled sooner than it should have been as a result of the rapidity of spread of the disease, and overcrowding of the hospital occurred when with a less rapid spread it would not have occurred; but whether the number of fatalities or the number of pneumonias was greater than they should have been with less crowded conditions may be doubted."

TABLE VII.

Relationship between crowding and number of cases in the family.

(Influenza appeared more frequently in crowded households and such families more frequently had multiple cases.)

Cases developing in family.	Total such families.	Invaded in 1918–19.		Invaded in 1920.		Invaded in both epidemics.		Total families invaded.		Two or more cases.
		No.	Per cent.	No.	Per cent.	No.	Per cent.	No.	Per cent.	Per cent.
Families with maximum per bed room of one. (58.23 per cent. of these had no influenza.)										
1	85	55	17.68	37	11.89	7	2.25	311	27.33	
2	32	26	8.36	16	5.14	10	3.22	...	10.28	
3	9	8	2.57	2	0.64	1	0.32	...	2.88	14.44
4	4	3	0.96	4	1.28	3	0.96	...	1.28	
5	0	0								
6	0									
7	0									
8	0									
2 per bed room. (43.35 per cent. of these had no influenza.)										
1	254	169	18.27	112	12.11	27	2.92	925	27.46	
2	135	112	12.11	64	6.92	41	4.43	...	14.59	
3	79	65	7.03	38	4.11	24	2.59	...	8.54	
4	40	35	3.78	16	1.73	11	1.18	...	4.32	29.17
5	11	9	0.97	8	0.81	6	0.64	...	1.18	
6	3	3	0.32	0	0.0	0	0.0	...	0.32	
7	2	2	0.22	1	0.11	1	0.11	...	0.22	
8	0	0								
3 per bed room. (35.34 per cent. of these had no influenza.)										
1	136	104	17.84	50	8.58	18	3.08	583	23.33	
2	103	77	13.21	55	9.43	29	4.97	...	17.67	
3	59	51	8.75	29	4.97	21	3.60	...	10.12	
4	43	40	6.86	16	2.76	13	2.23	...	7.37	41.33
5	22	22	3.77	9	1.54	9	1.54	...	3.77	
6	12	12	2.06	5	0.86	5	0.86	...	2.06	
7	2	2	0.34	0	.....	0	.....	...	0.34	
8	0									
4 per bed room. (30.79 per cent. of these had no influenza.)										
1	31	24	13.64	10	5.68	3	1.70	176	17.61	
2	22	19	10.80	13	7.39	10	5.68	...	12.50	
3	37	32	18.18	25	14.20	20	11.36	...	20.92	
4	14	11	6.25	6	3.41	3	1.70	...	9.09	51.60
5	9	9	5.12	4	2.27	4	2.27	...	5.12	
6	4	3	1.70	2	1.19	1	0.59	...	2.27	
7	3	3	1.70	0	.....	0	.....	...	1.70	
8	0									
5 per bed room. (35 per cent. had none.)										
1	8	6	15.00	4	10.00	2	5.00	40	20.00	
2	6	5	12.50	4	10.00	3	7.25	...	15.00	
3	3	2	5.00	2	5.00	1	2.50	...	7.50	
4	2	1	2.50	2	5.00	1	2.50	...	5.00	
5	4	2	5.00	3	7.50	1	2.50	...	10.00	45.00
6	2	2	5.00	2	5.00	2	5.00	...	5.00	
7	0	...	.....	...	.....	...	.....	...	.....	
8	1	0	0.0	1	2.50	0	0.0	...	2.50	
6 per bed room. (50 per cent. had none.)										
1	2	1	10.00	1	10.00	0	0.0	10	20.00	
2	1	1	10.00	1	10.00	1	10.00	...	10.00	30.00
3	2	1	10.00	1	10.00	0	0.0	...	20.00	
4	0									
5	0									
6	0									
7	0									
8	0									

The housing methods in the cantonments and even in the tent camps resulted in a degree of congestion and close physical contact among individuals that was attained in no civil communities with the possible exception of some institutions. In cantonments the number of men in individual rooms ranged from 30 to 100 and even under the best circumstances there was very evident close crowding. An individual in any of these large rooms contracting a contagious disease had opportunities to spread it by contact and by droplet infection not only to one or two others, as in the case of the average family, but to a large group of the men in the same room. A vicious circle was thus formed which tended to propagate the disease throughout any camp with utmost rapidity. Brewer has compared the influenza incidence rate in the principal white organizations at Camp Humphreys with the floor space allowed each man in the respective organizations, and concludes that, "It is not proper or just to attribute the differences shown, alone to the amount of floor space allowed each organization, but it certainly points very strongly to the fact that the incidence of the disease varied with the density of the population, although not with mathematical regularity." Brewer cites regiments which although housed alike showed definite variation in the influenza incidence. This merely shows that other factors also play a part. Thus, in one instance, the difference in the two regiments was in length of service. Brewer also found that among the white troops the incidence of pneumonia appears to vary with the density of the population.

V. C. Vaughan has reported on the relationship between incidence in tents and in barracks at Camp Custer. From this one observation it would appear that the incidence is little changed under the two conditions.

"During September and October, 1918, a study was made on the relationship, if any, of influenza to methods of living. Of the command, 3,633 were in tents. The morbidity per thousand in these was 129. There were in barracks 36,055. The morbidity per thousand among those was 275. At first glance the lower morbidity of those in tents is striking, but going further into the matter it was found that the entire morbidity of the Quartermaster Corps was very low. Of the Depot Brigade 2,881 were in tents, with a morbidity of 128 per thousand, while 3,824 were in barracks, with a morbidity of 134 per thousand."

Howard and Love offer three reasons why during the last four months of 1918 the deaths from influenza and pneumonia in the Army in the United States ran at a rate nearly three times as high as

that among our troops in France: First, that the troops in the United States were recent recruits and therefore more susceptible to disease; second, that probably many of the troops in France who had seen much longer service had had the disease in mild form in the early spring; and, third, that the method of housing was entirely different in France. There the men were spread over a wide territory and whenever in rest area they were billeted in houses rather than crowded into barracks. Furthermore, they were living much more in the open. It was found that in commands of the Service of Supply, where troops were housed in barracks with a large number of men to a single room, the epidemic ran much the same course with high mortality, as it did in the cantonments in the United States. The percentage of infection and the fatalities from influenza and pneumonia in France were much greater among troops of the S. O. S. than among troops at the front.

Domestic cleanliness.—We have studied the relationship between influenza incidence and the cleanliness of the household by the same method used in studying overcrowding. In Table VIII we have classified according to cleanliness and according to the number of cases developing in each family. We have had four subdivisions, "very clean," "clean," "dirty," and "very dirty." There is greater opportunity for erroneous results in this table than in the one preceding because the standards of cleanliness are difficult to define. As a matter of fact we are guided entirely by the inspector's own impression of each household, as she examined it during her visits. The following is an excerpt from the instructions given each inspector on this subject:

> "A few words on this subject may describe much. State of cleanliness of the individual, slovenly condition, dust and dirt, foulness of air noticed on first entering, condition of children, of kitchen sink, etc., should be noticed, and good or bad features recorded. In the poorer districts not a few families will be found in which the cleanliness, considering the surroundings, is quite laudable. Of particular importance are amount of daylight, ventilation, care of bathroom and toilet, garbage, whether windows are kept open at night."

On the basis of these returns we have classified the families as indicated, but each inspector was governed to a certain extent by the average cleanliness of her district, and it is difficult to compare the cleanest tenement with any of the districts of well-to-do individuals. We will therefore probably find it more profitable and more nearly

TABLE VIII.

Relationship between cleanliness and number of cases in family.

(Clean families were invaded less frequently and had solitary cases more often than did dirty households.)

Very clean.
(47.62 per cent. had none.)

Cases in families.	Total families.	'18.	Per cent.	'20.	Per cent.	Both.	Per cent.	Total.	Per cent.	
1	124	72	15.65	50	10.87	8	1.74	460	26.96	
2	53	41	8.91	27	5.87	15	3.25	....	11.52	
3	37	33	7.17	13	2.82	9	1.95	....	8.04	
4	18	16	3.48	8	1.74	6	1.30	....	3.91	
5	4	3	0.65	2	0.43	1	0.21	....	0.87	25.42
6	3	3	0.65	0	0.0	0	0.0	....	0.65	
7	2	2	0.43	1	0.21	1	0.21	....	0.43	
8	0	0	.....	0	.....	0				

Clean.
(41.52 per cent. had none.)

Cases.	Families.	'18.	Per cent.	'20,	Per cent.	Both.	Per cent.	Total.	Per cent.	
1	301	212	18.45	120	10.44	31	2.70	1149	26.19	
2	177	143	12.45	91	7.92	57	4.96	....	15.40	
3	101	83	7.22	52	4.53	34	2.96	....	8.79	
4	52	47	4.09	20	1.74	15	1.26	....	4.53	
5	30	29	2.52	17	1.48	16	1.22	....	2.61	32.29
6	8	7	0.61	3	0.26	2	0.17	....	0.70	
7	3	3	0.26	0	0.0	0	0.0	....	0.26	
8	0	0	.....	0	.....	0	.....			

Dirty.
(36.89 per cent. had none.)

Cases in family.	Total families.	'18.	Per cent.	'20.	Per cent.	Both.	Per cent.	Total.	Per cent.	
1	79	59	17.40	36	10.62	16	4.72	339	23.30	
2	58	48	14.16	29	8.55	19	5.61	....	17.11	
3	37	31	9.14	22	6.49	17	5.01	....	10.91	
4	26	22	6.49	12	3.54	8	2.36	....	7.67	
5	6	5	1.79	4	1.18	3	0.94	....	1.77	39.81
6	7	7	2.06	4	1.18	4	1.18	....	2.06	
7	0	0	.....	0	.....	0	.....	....	.....	
8	1	0	0.0	1	0.29	0	0.0	....	0.29	

Very dirty.
(39.26 per cent. had none.)

1	22	16	14.95	8	7.47	2	1.85	107	20.56	
2	11	8	7.47	6	5.10	3	2.80	....	10.28	
3	14	12	11.21	10	9.35	7	6.54	....	13.08	
4	7	5	4.67	4	3.73	2	1.85	....	6.54	
5	6	6	5.10	1	0.93	0	0.0	....	5.61	40.18
6	3	3	2.80	2	1.85	2	1.85	....	2.80	
7	2	2	1.85	0	0.0	0	0.0	....	1.87	
8	0	0	.....	0	.....	0				

accurate to combine the groups and classify them only as "clean" and "dirty."

But even without combining in this way, the table shows us that for both years 27 per cent. of the very clean families, 26 per cent. of the clean, 23 per cent. of the dirty and 21 per cent. of the very dirty, had but one case, while 25 per cent. of the very clean, 32 per cent. of the clean, 40 per cent. of the dirty, and 40 per cent. of the very dirty, had multiple cases.

The cleaner the family the less is the likelihood of multiple cases.

It is rather difficult to find concrete examples of the influence of domestic habits and environment in the 1918 pandemic. The remarkably high incidence among the natives of India and among the American Indians might by some be attributed to unfavorable environment. Lynch and Cumming obtained records from a large number of institutions and from business concerns having their own records, and discovered that the influenza incidence was higher in those institutions where dish washing was done manually than in those in which mechanical washing was performed. They appear to conclude that the difference in the two methods of washing dishes was the cause for the greater incidence in influenza, thus bearing out their theory of the propagation of influenza chiefly through eating utensils. On the contrary it is possible that the presence of the mechanical washer is an indication of advanced methods, greater care in the kitchen, and better hygiene probably not only in the kitchen and dining room, but throughout the institution.

Economic status.—Although in our survey information has been obtained regarding the economic status of the various families we would not stress this phase of our subject. Obviously the amount of money an individual has in his bank will not directly influence the amount of influenza he will have in his home. As nearly an accurate classification by wealth is by the separation into the districts, Districts I and III being very poor, District II poor, Districts IV and V moderate, and VI well-to-do. From Chart XXVI we see no definite relationship between influenza incidence and economic status.

Dr. Niven has had similar experiences. He remarks that the disease does not appear to have affected especially any class or section of the community. Rich and poor suffered alike. Inquiry in some towns shows that the epidemic not infrequently started in the well-to-do districts and only later involved the poorer and less prosperous areas.

We cannot state with any degree of accuracy in what section of

Boston the 1920 recurrence first began. The sections studied are for relatively small portions of the city, and it is possible or probable that the original increase was in some area outside of our districts. In the districts studied the earliest increase in reported cases was from the section of the city known as Dorchester (Districts IV and V), where there was some increase in December, 1919. The latest definite increase was in the Irish district of South Boston. Geographically these two areas are quite near. The relative insusceptibility of the Irish population is probably a much more important factor in the difference.

Frost found after classifying the white population canvassed in Little Rock and San Antonio according to economic status, and adjusting the incidence rate in each group to a uniform sex and age distribution, that the ratios of incidence in each economic group to incidence in total white population did show an increase with increasing poverty. "Notwithstanding that the classification according to economic status is a very loose one, based solely on the judgment of inspectors with widely different standards, a considerably higher incidence is shown in the lower as compared to the higher economic group."

Parsons, in 1891, discussed the influence of poverty, but believed that it is the concomitants of poverty which were the cause of the higher incidence among the poor.

"Sanitary conditions do not seem to have had any influence in determining the occurrence of influenza, and what share they have had in determining its extent or fatality cannot yet be decided. On the occasion of the last great epidemic, Dr. Peacock concluded, 'The more common predisponents to disease, *e. g.*, defective drainage, want of cleanliness, overcrowding, impure air, deficient clothing, innutritious or too scanty food, powerfully conduce to the prevalence and fatality of influenza.' And Dr. Farr showed that in the last six weeks of 1847, while in the least unhealthy districts of London the annual rate of mortality was raised from a mean rate of twenty per 1,000 to thirty-eight, in the unhealthiest districts it was raised from a mean rate of twenty-seven to sixty-one.

"That overcrowding and impure air must have a powerful influence in aiding the development of the epidemic follows from what we have seen of its greater prevalence among persons associated together in a confined space; and though rich and poor have alike been sufferers from the epidemic, and even royal personages have been fatally attacked by it, it cannot be doubted that poverty must have in many cases conduced to a fatal issue in persons, who, if placed under more

favorable circumstances, might have recovered, seeing that it often involves not only inferior conditions of lodgment, but also want of appropriate food, of sufficient warmth and clothing, and of ability to take the needed rest."

Distribution of the disease through the household.—During the autumn and winter epidemic of 1918 there was considerable discussion, and particularly were there popular newspaper reports of entire families being taken ill with influenza, sometimes all on the same day. This was less true of 1920. But few of us are personally acquainted with such instances and at best they must have been relatively rare.

Among 1,236 families with influenza in either epidemic we found only 94 or 7.6 per cent. in which the entire family contracted the disease. No family consisting of over seven individuals was reported as having all the members of the family sick in either epidemic. Over two-thirds of the families with even numbers of individuals (464 out of 605) suffered the illness of less than half of the household. One quarter of all families of more than one (539 out of 2,107) had but one case per family. Over a third of all families of over two inividuals (745 out of 2,006) had two or less cases per household. *As a rule there were at least one and usually several individuals in each household who did not contract influenza.*

That as a rule the disease did not appear explosively in a family; but that cases developed successively, is indicated by the fact that out of 577 families contracting influenza in the epidemic of 1920 the cases were all of simultaneous development in but fifteen. In thirteen of these, two individuals fell ill on the same day and no subsequent cases developed. In the other two families three individuals came down on the first day and no other cases developed. In addition there were, out of the 577 families, fourteen in which there were two or more cases developing on the first day of the invasion, but which were followed on subsequent days by later cases in the same family. Again, there were eleven families in which two or more cases occurred simultaneously at an interval of one or more days after the development of a single prior case.

We may say that *as a rule in the* 1920 *epidemic, cases of influenza developed in families successively and not simultaneously.* In only 29, or 5 per cent. of the families contracting the disease in 1920, did more than one case develop on the first day of the appearance of the disease in the family.

A certain difficulty in determining the date of onset is that we must rely upon the patient's statement. One individual may have been

sick for hours or days before a second member coming down with the disease called forth recognition of the fact that they both had it.

Unfortunately we are not able to give similar statistics for the 1918–19 epidemic. Our investigation occurred so long after the epidemic that specific dates of onset of the disease would have been entirely unreliable. The nearest date we have attempted to obtain was the month of the attack.

Dr. A. L. Mason states that 63 cases came under his observation in the epidemic of 1889 as occurring in groups in families. In but six instances were two persons attacked on the same day. The average interval between cases in the same household was four days. Sometimes a week or more elapsed. Whole families were never stricken at once.

Parsons in 1891 concluded from the results of questionaires sent to physicians that in the first spread, 1889–90, there was an interval between cases in individual households just as we have described. Among the replies to his questionaires nine described intervals of one day and under, six described intervals of two days, three of three days, three of four days, and four replies described intervals of more than four days.

Leichtenstern observed likewise: "In large families the contagious character of influenza is evidenced by the fact that the other members of the family become sick one after the other following the first case. This rule of succession is most easily seen in the early or late period of an epidemic and is less noticeable at the height, where the opportunity for all the members of the family to acquire the influenza outside the home is enormous. This latter fact explains why, when all sicken at once, the disease appears to be miasmatic in origin. There are many examples where other members of a family living with a sick individual remained unaffected. Parsons reports such cases, and this was so frequently the case that some British physicians state that it is the rule that there is but one case in a family or that the cases are widely separated in time. This was only partly true during the period of the pandemic and was very frequent in the epidemic following it. In this respect influenza acts like the common contagious diseases, diphtheria, scarlet fever, measles, etc., while the difference lies in the short incubation period and the very high contagiousness of the disease."

That West, in England, had observed the same phenomenon is indicated by the following quotation: "How is it, for instance, that one member of a household may be picked out and the others escape,

though they are susceptible, as is shown by their acquiring the disease shortly after in some other way?"

Again Leichtenstern wrote: "It is noteworthy that influenza on ships usually did not occur explosively, but spread gradually, and on ships usually lasted several weeks, as on the Bellerophon, from the 27th of March to the 30th of April; on the Canada from the 11th of April to the 24th of May; on the Comus from the 10th of April to the 3d of May.

"The German Marine Report states, 'Everywhere on the ships the disease began not suddenly but gradually.' The frigate Schwalbe first had a large number of cases only on the 6th day after the beginning of the epidemic. There are, however, some exceptions, where the disease has begun suddenly with the greatest violence on ships as on land. Such was true of the frigate Stag which on the 3d of April, 1833, neared the influenza infected coast of Devonshire, and as it came under the land wind the epidemic suddenly broke out with great violence. Within two hours forty men took sick. Within six hours the number had increased to sixty. Within twenty-four hours 160 men were sick. As Parkes has remarked the evidence is insufficient that there had been no communication with the coast. There have been other examples of sudden outbreaks on ships, as on a Dutch frigate in the harbor of Mangkassar, where 144 men out of 340 took sick in a few days (1856); on the Canopus (1837) in the harbor of Plymouth, where on the 15th of February three-fourths of the men took sick with influenza."

Garvie, in reporting his personal experiences with influenza in 1918 in an industrial area in England, experiences not based on statistical study, concludes that there are two types of cases, the sporadic case which occurs mainly among the wage-earning members of the family and has little tendency to affect other members of the household, and second, the type of case where a large number of individuals in the household are affected. He called this the "household wave." If we interpret him aright he really means that there are either single or multiple cases, and that the single cases are more apt to occur in the wage-earner, the individual who is more exposed on the outside of the household. He also believes that the household wave is more severe in character than the so-called sporadic case, and is accompanied by a greater number of complications.

Armstrong, in his survey in Framingham, examined influenza convalescents. He found that of these 10 per cent. were in families in which no other cases had developed, and 87 per cent. were in families

where one or more additional cases had occurred. In three per cent. information was lacking.

It is important in studying the literature on this subject to distinguish between definitely established fact and less definite description. Thus one is still left in some doubt when one reads in a London letter in the Journal of the American Medical Association for 1915 concerning the epidemic in London at that time that, "whenever it has seized an individual it has usually run through the entire household. Whole offices have succumbed."

The first case in the family.—Chart XXVII shows clearly that in both epidemics in our experience the wage-earner was much more frequently the first case in a family than was any other occupation. The individuals whose occupations kept them at home were second. Infants, as was to be expected, were recorded as being "first case" in the smallest number of instances.

In 1889 the distribution was practically the same. Parsons found that out of 125 households the first case was a bread-winner in 96; a housekeeper in nine; a child at school in thirteen; a child not at school in two families. In the last five families the first case was in adults, occupation not given. This order is identical with our own. Neither our own observations nor those of Parsons consider the relative proportions of wage-earners in the population as a whole. The results are nevertheless suggestive.

H. F. Vaughan reached comparable results for the 1920 epidemic in Detroit. During the first few weeks the age groups from 20 to 29 showed a relatively much more frequent influenza incidence than did children up to ten years. In later weeks of the epidemic there was a relative increase in the incidence among children and decrease among young adults. He concluded that the disease first attacks the young adult and from this group it extends into the home.

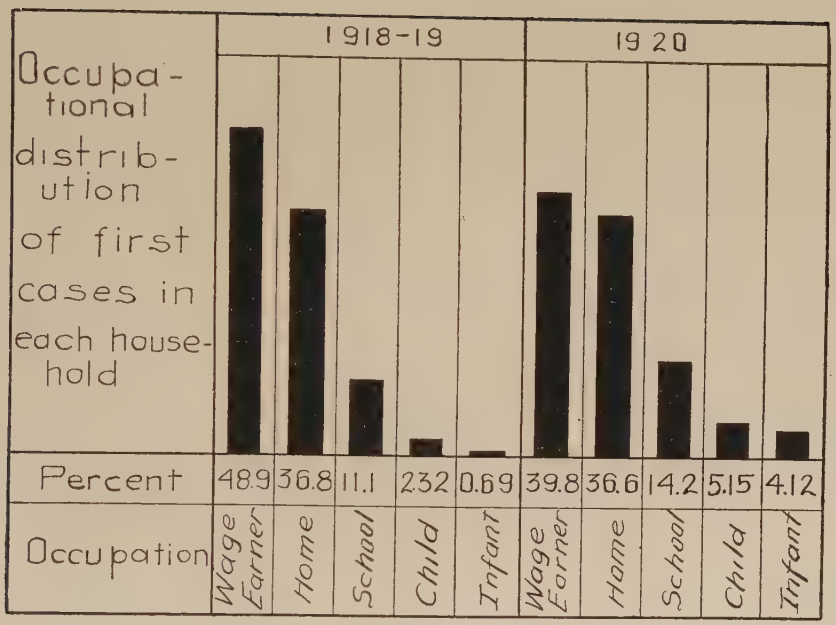
In the Local Government Board Report for 1891, H. H. Murphy distinguishes three groups or ways in which the disease may be brought into the family. The examples will be found to be characteristic for any epidemic and for any country:

Group A.—Cases of single exposure.

"Household 1.—Mr. Q. goes to London daily. Was ill with influenza on December 25th. No other case in this house till January 15th.

"Household 2.—Mrs. A. called on Mr. Q. on December 31st, and had a few minutes' conversation with him. She was taken ill on January 3d. There was a Christmas family gathering at this house, and this is how the other members were affected: Mr. B., January

CHART XXVII.


Occupational distribution of first cases in each household
1918-19
1920
Percent
48.9
36.8
11.1
2.32
0.69
39.8
36.6
14.2
5.15
4.12
Occupation
Wage Earner
Home
School
Child
Infant
Wage Earner
Home
School
Child
Infant

6th; Miss C., Mrs. D., and Master D., January 8th; Mr. J., January 10th; Mr. H., January 11th.

"Household 3.—Miss M. went to a party January 3d. She had a few minutes' conversation with a young lady who said she was suffering from influenza. Miss M. had a characteristic attack on the 6th of January.

"Household 4.—Mr. G. goes to London daily; taken ill January 5th. Mrs. N. visited him for a short time on January 5th, and was taken ill January 10th."

Group B.—Where disease was brought from a distance into a previously healthy household.

"Household 8.—Mrs. R. G., living in the north of London, came here on a visit December 17th. On the 19th she was taken ill with influenza, the first case that I knew of in this neighborhood. Mr. C. G., on the 23d, servant on the 26th, Mrs. G. 31st, and Mr. G. January 9th.

"Household 9.—Mr. I. lives at his business place in London, taken ill December 20th with influenza. His family reside here. Boy C. visited his father for a few days, and came back ill on January 4th. The other members of the family were attacked as follows: Baby, 8th; Mrs. and boy, 12th; boy, 18th, girl, 22d; girl 25th.

"Household 10.—Master K. stayed a few days with some friends in London. They had been ill with influenza. Returning home on December 31st he was taken ill. Four brothers and sisters ill on the 2d January, Mr. K. on 3d, child and two servants on the 5th, Mrs. K. on the 7th."

Group C.—Where the source of infection could not be determined or was local.

"Household 28.—Mrs. D. (who thinks she got it shopping) was taken ill 2d January, her daughter on the 5th, and Mr. D. on 6th.

"Household 29.—Mrs. L. (who thinks she got it shopping), aged 80, had influenza badly in 1847; similar symptoms, but much milder, on January 6, 1890; Miss L. was attacked on the 10th, and servant on the 17th.

Note.—A former attack did not confer immunity after forty-three years.

"Household 30.—Mrs. B. (who thinks she got it out at work) taken ill 9th January, and her child on the 11th."

In Murphy's complete list, one of the most frequent remarks is, Mr. Blank goes to London daily. Or, Miss Blank, absent on a visit, was taken ill with influenza and returned home.

Again, in 1890, Dr. Bruce Low studied the development of influenza at East Keal, a town of 300 inhabitants. We quote in part his description:

"The following is believed to have been the commencement of the outbreak, and for these facts I am indebted to Dr. Francis Walker, Medical Officer of Health, Spilsby, R. S. D. Mrs. N., residing at East Keal Hall, went to London (Forest Hill) on a visit on November 11th. She visited Barnum's Show on November 13th. She became ill on the night of the 14th. Her symptoms were those of a cold, attended with sore throat. No one else so far as she knew was ill in this way in the house before her. She left Forest Hill on November 16th, still feeling very unwell, and went to stay with friends at Kensington. She was too ill to return home till November 23d, at which time she was still feeling very weak. She heard from Forest Hill that, directly after she left one of the inmates of the house where she had been visiting fell ill with symptoms similar to her own. Within a few days, probably about the 27th of November (the exact date is not fixed), of her return home, her son, aged four, became unwell with what appeared to be an ordinary cold, but the child had epistaxis; he soon recovered, but during the next fortnight the four servants in the house were ill with what were said to be 'colds,' one of them also had epistaxis. On January 2d another son, aged six, was ill with 'cold' for a few days; he went out and had a relapse, which compelled him to stay in the house for another week.

"On January 3d, Mrs. N. again fell ill with 'a bad cold,' attended with headache, backache and epistaxis. She was in bed two days and felt miserable and prostrate for more than a week after. On January 5th, Mr. N., her husband, had headache, backache, and general soreness 'all over.' On January 10th, the boy, aged four, who was first attacked after his mother's return from London, again became ill, his symptoms being the same as before. The only other remaining member of the family who had managed to escape an attack of 'cold' up to this date, was said to have felt ill the day the boy had his second attack; but the illness of this individual was slight, and only caused suffering for one night. Thus between the return of the mother on November 23d and January 10th all the inmates of this house, nine in number, had an attack of illness, evidently of the same nature. A boy who works in Mr. N.'s yard was taken ill with influenza about the end of November. He lives in the village. After his illness his four brothers also were ill. Dr. Walker says that 'about the end of November' cases of like illness were beginning to crop up in East Keal.

Mrs. W., the wife of the village grocer and baker, who waited on customers in the shop and never left the shop or house, was taken ill on the afternoon of November 30th. Next morning, December 1st, her husband and six children were all attacked in the same way with what is now recognized to have been marked influenza. The only inmate of the house who escaped was a youth employed to deliver bread and groceries in a cart in the neighboring village."

Leichtenstern relates that a physician traveling from Berlin on the 10th of December became sick in his home town, Elgesburg, on the 8th of December, but he made several visits and a few days later those people seen by him fell sick, while otherwise there were no cases of influenza in the town or its neighborhood. These cases would probably have fallen in Group C., of Murphy's classification.

Intimacy of family contact.—We have been able to discover in a representative number of families in which influenza has occurred, not only what individuals slept in the various rooms of the household, but also what individuals slept in the same bed with influenza cases. We can, therefore, study for the 1920 epidemic three degrees of contact; contact by sleeping with a case of influenza; by sleeping in the same room but a different bed; and general contact by being in the family, but sleeping in another room. For brevity we designate these, *"sleeping," "room"* and *"family" contact.* We have established similar information for 1918, after eliminating families in which deaths or births or other additions or losses had occurred during or subsequent to the 1918 pandemic, in which there has been a change of address, in which the cases are so widely separated that we have designated them *unrelated*, and finally, those families in which the information has been insufficient. With the remaining we have assumed that the distribution within the household has been the same in both epidemics. Statistics are available on 1,734 individuals who in 1918 were exposed to a prior case in the family. Of these, 462 developed influenza and 1,272 did not. 26.6 per cent. of exposed individuals in families contracted influenza, without respect to the degree of exposure.

Intimacy of contact.	Number so exposed.	Number infected.	Per cent. infected.
"Sleeping"	360	166	45.2
"Room"	303	59	19.5
"Family"	1,064	273	22.3

45.2 per cent. of individuals sleeping with cases of influenza in 1918 contracted the disease; 19.5 per cent. of those sleeping in the

same room, but different beds did so; 22.3 per cent. of those living in the same family, but sleeping in other rooms contracted the disease.

Sleeping contact is more productive of influenza than are the less intimate forms.

Throughout this study the fact that there are multiple possible sources of infection both outside and often within the family complicates the picture.

The results for 1920 are similar. Here, 30.0 per cent. of all individuals sleeping with cases of influenza contracted the disease, 17.7 per cent. of room exposures contracted it, while but 11.5 per cent. of family exposures were attacked.

Four hundred and sixty-three or 29.1 per cent. of the total of 2,193 individuals exposed in 1920 had had the disease in the 1918 pandemic. Did they show by reason of any immunity a lower attack rate for the same degree of exposure than other individuals in 1920?

Type of exposure in 1920.	Per cent. of exposed individuals who had had influenza in 1918–19 and who contracted it again, per cent.	Per cent. of those who had not had a previous attack, and who on exposure contracted influenza, per cent.
"Sleeping"	27.0	31.0
"Room"	18.3	17.6
"Family"	12.0	11.2

On the whole there is no evidence of protection afforded by a previous attack.—Individuals who had had the disease before succumbed to a second attack in the same proportion as those who had not previously had influenza.

Recurrent cases.—In certain families there were individuals who had had influenza during both the 1918 and 1920 epidemics. Were these recurrent cases the first ones to occur in the family, or did they, as a rule, follow other cases in the same household? We have records of 236 recurrent cases in which we know the order of occurrence of the various cases in the family. Out of this total number 57 were the initial cases in the household. One hundred and nineteen were the only cases occurring in the family. Therefore 176 or 74 per cent. of the total number of recurrent cases were either the first or the only cases in the family. Sixteen recurrent cases followed between other cases and 44 occurred as the last of a series of two or more in the household.

SECTION V.

Immunity.

Opinions of all observers who have studied in detail the question of immunity in influenza are remarkedly in accord. The conclusions reached by Parkes in 1876 are valid today, and form as excellent an abstract of our present knowledge as any produced since his time. "There is some discrepancy of evidence, but, on the whole, it seems clear that, while persons seldom have a second attack in the same epidemic (though even this may occur), an attack in one does not protect against a subsequent epidemic. Indeed, it has been supposed rather to render the body more liable."

In 1890, Abbott wrote: "There is but little if any evidence in support of the protective power of one attack to confer immunity against a second; and hence adults are not exempt, as they usually are in epidemics of scarlet fever or other exanthemata; so that the proportion of adults to children attacked in an epidemic is necessarily greater than that which is observed in epidemics of other infectious diseases."

Parsons made somewhat similar observations: "One attack of influenza does not seem to be protective against another; the disease in this respect resembling diphtheria, erysipelas, and cholera rather than small-pox, measles, or whooping cough. The duration of the epidemic in a locality is so short that it is difficult to distinguish between second attacks properly so-called, and relapses, which are frequent enough. A case is recorded in the 'British Medical Journal' of February 15, 1890, in which a patient who had suffered from influenza in France in December, 1889, had another attack in England in January, 1890. It was noticed in 1837 that many persons suffered from influenza who had had the disease during the previous epidemic in 1834. The shortness of the interval between these two epidemics, as compared with that between 1848 and 1889, seems to show that the periodical return of the disease in an epidemic form does not depend upon the accumulation in the interval of susceptible individuals unprotected against the disease by a previous attack. If one attack afforded protection against another a large proportion of the population in 1837 must have been protected, yet an epidemic occurred, and on the other hand for many years before 1889 a large majority of the population must have been unprotected by a previous attack, yet the epidemic did not recur.

"The persons now living who passed through the disease in 1847 are of course comparatively few, but such persons have not been exempt from the present epidemic.

"I should be inclined to attribute the short duration of the influenza epidemic in a locality to the establishment of a tolerance for the specific poison among the persons exposed to it, similar to the tolerance for dust possessed by workmen in rag factories, as mentioned, but which is soon lost on their ceasing to be exposed to it, rather than to a true immunity being established.

"Relapses in influenza are of frequent occurrence; they occurred in 9.2 per cent. of the cases at the Morningside Asylum, Edinburgh, and in some cases indeed a second relapse has been recorded. The time at which the relapse occurs is usually from a week to a fortnight after the primary attack, and it can often be distinctly traced to an exposure to cold, or return to work before complete recovery. The symptoms of the relapse are similar to those of the primary attack, except that they are commonly more severe."

In his report of 1893, Parsons goes into the subject of recurrent attacks in individuals in greater detail. He quotes several communications received from various physicians and health officers. These opinions differ, some believing that the disease predisposes to another attack; others, that there is no effect on the incidence in recurring epidemics; and still others believing that there is a small amount of acquired immunity. The communications are not based upon statistical evidence. He does find, however, an opportunity for statistical study in the industrial schools at Swinton near Manchester: "These schools were severely affected in March, 1890, 171 out of 589 children having suffered, or 29 per cent. In the first epidemic of 1891 they were again affected, but to a less extent, only 35 cases occurring. At that time there were in the schools 449 children who had been there at the time of the former epidemic. Of these 150 had had influenza in 1890 and 4 of them had it again, or 2.6 per cent.; 299 had escaped influenza in 1890 and 17 of these had it now, or 5.7 per cent. Thus, so far as these figures go, an attack of influenza confers a degree of protection which after the lapse of a year diminishes by one half the liability to contract the disease."

Leichtenstern, like Parsons, recognizes the importance of distinguishing between relapses and recurrent cases. Relapses in influenza are not common. They usually occur after the patient is up, and about when he is ready to leave the house. These are not recurrent cases, but in the epidemics in the years following 1889 there were

plenty of well substantiated cases of recurrent typical influenza in the same individual and some times even in entire families. During the 1889 epidemic, as during the 1918 epidemic it has been suggested by various observers that the apparent immunity among the very old was due to immunity developed as the result of previous epidemics, such as that of 1837, 1847 and 1857. Leichtenstern has collected the statistics from five different hospitals in which 8, 32, 35, 24, and 24 per cent. of individuals attacked in 1891–92 had already had the disease in 1889.

Allbutt in 1905 remarked that whereas he had previously believed that immunity to influenza usually persists as long as six months, many cases had recently been brought to his notice where such an interval seemed improbable, where the succeeding attack was probably not a relapse but a new infection. He has seen two attacks apparently separate occurring in the same individual within two months. In the same year Moore wrote that influenza shows a decided tendency to relapse, a feature to which the indirect fatality of the disease is in great measure due. "So far from establishing immunity, an attack of this malady seems to render an individual more liable to contract the disease upon any future exposure to its contagion."

Again West, in the same year wrote, "From our present experience we must conclude that influenza is infectious in a very high degree indeed, and that the protection afforded by an attack is imperfect, or of very short duration. Indeed, one attack seems actually to predispose, after a time to another, or, to put it differently, that the positive phase of protection is followed by a negative phase, in which the individual seems rather more than less liable to succumb to infection if exposed to it. It seems more likely that an individual may never have influenza at all than that, having had it once, he should never have it again. Some, indeed, seem to offer so little resistance that they develop it regularly once or twice a year."

We have previously shown that the relatively low morbidity among the older age groups in 1918 is not satisfactorily explained by an immunity lasting over from the epidemic of 1889–93. If such were the case the change in mortality rate in large groups of individuals would occur at the age of 30.

During the autumn of 1918 many observations were made, particularly in the armies, of light incidence in those groups or communities that had had the disease in mild form in the spring of the same year.

Parsons quotes many similar observations for the period 1890–1893.

V. C. Vaughan relates that at Camp Shelby, Mississippi, "there

was in April a division of troops numbering about 26,000. An epidemic of mild influenza struck this camp in April, 1918, and within ten days there were about 2,000 cases. This included not only those who were sent to the hospitals, but also those who were cared for in barracks.

"This was the only division that remained in this country without change of station from April until the fall of 1918.

"During the summer this camp received 20,000 recruits. In October, 1918, the virulent form of influenza struck this camp. It confined itself almost exclusively to the recruits of the summer and scarcely touched the men who had lived through the epidemic of April. Not only the 2,000 who had the disease in April, but the 24,000 who apparently were not affected escaped the fall epidemic. It appears from this that the mild form of influenza of April gave a marked degree of immunity against the virulent form in October. There is another observation which points the same way. Looking over the statistics of the fall epidemic in cities in the United States we find that certain cities had a low death rate, while others had a relatively high rate. Among those cities which had a low death rate we will mention Atlanta, Ga.; Kansas City, Mo.; Detroit, Mich., and Columbus, Ohio. Going to the spring records of these cities we find that in all of them in March and April of 1918 there was an unusually high death rate from pneumonia and undoubtedly in these cities at that time there was a relatively mild epidemic of influenza. In this way I am inclined to account for the relatively low death rate in these cities in the fall of 1918. I make no claim that this and other instances of a similar kind prove that the mild and virulent forms of influenza are manifestations of the same disease, but I do hold that the evidence points that way."

Lemierre and Raymond report the following observation in favor of the development of a certain degree of immunity in the French troops in April, 1918. After an intervening period of quiescence there was a manifest recrudescence at the end of August. Many military formations were attacked during both periods. This was true especially in three groups of an artillery regiment under their observation. In the first of these groups there were three cases in April, while 114 men were attacked in August. In the third group there were 100 cases in April and only 3 in August. In the second group there were 20 cases in April and 59 in August. Their report does not state the total number of individuals in each of the three groups.

Joltrain and Baufle discuss the flaring up of the epidemic in October, and relate that a troop of soldiers from Indo-China nearly all had the disease lightly in the spring, but when the disease appeared again it spared this troop completely, while troops and civilians around developed it in a severe form.

Gibbon writes: "During the last three waves of the epidemic I had to deal with the sick of 2,000 troops, and during this time we treated in hospital over 400 cases. No cases admitted in June, July or August were re-admitted in October, November, or December, and no cases admitted in either of these two periods were re-admitted in February this year. Unfortunately I am unable to trace the cases into March as the troops were changed."

Dopter reports recurrent epidemics of influenza in a French Army Division in 1918. The division, of which he was surgeon, was one of the first to contract la grippe at the time of its first appearance in the zone of the armies at the end of April, 1918. At this time nearly the entire body of infantry troops was attacked. The disease was mild, and without complications. The regiment of artillery escaped nearly entirely. This epidemic subsided very rapidly, and by the end of May it had entirely disappeared. Early in August a group of heavy artillery was attached to the division, bringing influenza with it. Then a few cases appeared in the regiment of light artillery which had hitherto escaped. By the end of August all three groups of this regiment had been attacked. In this second epidemic the men who had come through the first unattacked were very severely ill in the second.

With rare exceptions those sick in the first did not contract it again. Dopter notes that in the battery the most severely affected in August, of which the effectives were reduced almost to none, only those men were considered well enough for duty who had had influenza in the first period. They escaped the second in spite of the close contact with their comrades. The infantry regiments, which were in close association with the artillery, remained unaffected.

Finally, toward the middle of September new troops were attached to the division, in view of an imminent attack by the enemy. These troops, coming from neighboring and distant formations were suffering at the time from grip, and continued to have the disease in the new sector. Again, those attacked in May passed without damage through this new epidemic. Among them there were only rare isolated mild cases. The recurrences made only 1.6 per cent. of the total incidence.

Opie and his associates found that at Camp Funston after the first wave of influenza in March and April, 1918, the succeeding waves

usually affected only new recruits, who had not been in camp during previous waves.

In Calcutta influenza appeared as an epidemic in July, 1918, and in November, 1918. During the first quarter of 1919, at Calcutta as elsewhere, many cases were still recurring. Malone investigated the incidence of the disease in three institutions of Calcutta: He found that in the Gourepore Jute Mills where the population was practically stationary, those individuals who were attacked in July, 1918, passed through two later epidemics, in December, 1918, and February, 1919, without contracting the disease a second time, in spite of intimate contact with infected persons. The same was true according to Malone in the Alipore Central Jail and the Presidency Jail in Calcutta. He believes that his evidence strongly suggests an immunity lasting for at least nine months.

Dunlop found that Glasgow had a mild epidemic in the month of May, 1918, in which the death rate rose from 14.1 to 20.1. There is no record of any similar outbreak in Edinburgh. In the July epidemic the Glasgow death rate rose from 11.7 to 15.9, while the Edinburgh death rate went from 11.3 to 18.0, a higher increase. In the October-November epidemic the Glasgow rate rose from 11.0 to 38.4, while the Edinburgh rate went from 10.8 to 46.2. In the February-March epidemic the Glasgow rate rose from 14.9 to 48.3, and the Edinburgh rate from 18.9 to 52.1 In the July and October epidemics Edinburgh showed a greater increase in death rate, while in February, 1919, the increase in the two cities was the same. However, in this case probably other factors play a part. Also, we must remember that here we are dealing with death rates, not with incidence rates.

The Inspector General of Health, in Spain, reported in January, 1918, that those cities which had the disease in May, 1918, suffered lightly in the autumn of that year, while others of the large cities which had been spared in the first invasion suffered most in the second.

Maillard and Brune report an epidemic of influenza in an epileptic colony. There were 32 deaths among the 63 cases. None of the inmates of the hospital who had influenza during the June epidemic contracted it anew during the October wave.

Ovazza records that although a number of persons contracted the influenza anew on its return in the fall after having had it in the spring, yet the return cases were strikingly mild, and always free from complications.

Barthélemy describes the successive waves of epidemic influenza at Bizerte. He found that the doctors and nurses who had been

through the first epidemic did not develop influenza in the second one a few months later, even though they came in the closest contact with the patients.

Hamilton and Leonard have studied two successive outbreaks due to lapses in a rigid quarantine in an institution of 180 girls between 12 and 18 years of age. The girls were distributed through six cottages. In the first epidemic November, 1918, 76 girls contracted the disease, at which time it was entirely limited to the occupants of cottages 2, 3, and 4. The second outbreak occurred in January, 1919, when 82 took ill. Only five of these were located in cottages 2 and 4, the remainder being in 1, 5 and 6. No cases occurred in cottage 3 during the second spread. Both epidemics lasted a little under two weeks. Those who had suffered in the first spread appeared to be immune to the second. There were no recurrences. The second epidemic was much milder in character. Twelve per cent. of the total remained well throughout both epidemics.

Dr. Niven, in his study of 1,021 households previously described, found that 105 families suffered in both the summer and autumn 1918 epidemics. "They comprised a population of 565 persons, of whom 205 suffered in summer and 360 escaped. In the autumn epidemic eighty-two (or 40 per cent.) of the presumably 'protected' persons succumbed again, whereas only 120 (or 33 per cent.) of the 'unprotected' suffered. Of the former, however, only one died, while five of the latter terminated fatally. These are interesting figures. If they are borne out by subsequent inquiry, they are somewhat difficult of explanation. The persistent susceptibility to the primary disease and yet comparative immunity from the fatal sequel, would seem to suggest a dual infection, against one element of which the body is able to produce protection, while it is unable to do so against the other."

Frost made a canvass of 33,776 individuals in Baltimore between November 20th and December 11th, 1918. The same population was again covered in January, 1919, to determine the extent of the recrudescence reported in December. Among 32,600 people, 724 cases of influenza had occurred in the interval since the first survey. Of this number only 26 or 3.6 per cent. were definitely cases of second attack in the same individual. Even in these cases the diagnosis is necessarily uncertain. Frost says that considering that 23 per cent. of the population had had influenza prior to December 11th, the proportion of second attacks should have been much greater if no immunity had been acquired. A second canvas in San Francisco gave generally corresponding results.

Our own experience was quite similar. We have divided the whole period from March, 1918 to March, 1920, into two portions separated at August 1, 1919. In the first portion we have knowledge of but four individuals suffering from what the records would indicate to be two genuine attacks of influenza. Similarly, five individuals appeared to have had two attacks within the second interval. These are to be contrasted with a total incidence in the fall and winter of 1918–1919 of 1,971 cases, and in the winter of 1919–20, of 965 cases. Among the total nine individuals the intervals between attacks varied from 26 days to five months. All except one had an interval of one month or over. In two cases there was an interval of one month, in one an interval of two months, in two an interval of three months, in one of four months, and in one of five months. None of the four individuals who had two attacks in the first group of months had a subsequent attack in the second. On the contrary, two of the five suffering two attacks in the second group of months had one previous attack in the first. The second attack, following the first by a relatively short interval tended to be milder than the first. In five out of the entire nine the second attack was milder, in two it was of the same degree of severity, and in only two was it more severe than the first. The order of severity in the two individuals having three attacks each was, in the first, severe, mild, severe; in the second, severe, average, average.

Zinsser makes the following remark: "The writer himself believes that he had three attacks during the last epidemic. The first and second were mild ones and the third complicated and therefore severe; and innumerable others with whom he has spoken have had similar experiences."

From a consideration of these reports by divers authorities it is reasonable to conclude that for a period of a few months at least, one attack of influenza protects against a second. As is to be expected, this relative immunity is not of constant duration in all individuals. If there were no lessened susceptibility following an attack we would be faced with the phenomenon of individuals succumbing time and again to rapidly successsive attacks of the disease. Such a circumstance is very rare.

It is difficult to determine how long even on an average this relative protection or insusceptibility lasts. Evidence is fairly uniform in indicating a protection of at least three months. Usually it is longer. There seems to be some basis for the supposition that a group of individuals exposed to an attack of influenza displays within the succeed-

ing three months, or slightly longer, a relative general group immunity. If the group be considered as a whole those even who did not develop the disease previously appear to have become less susceptible. Whether we can ascribe this to the individual as a unit, or whether we must explain it by some assumption with the community as a unit, is uncertain. Is it because the exposed individuals in the group who did not contract the disease have individually received some of the virus into their systems and developed a certain immunity, or is it a much more complex phenomenon depending on greater relative dispersion of susceptibles and other communal factors?

We may place the minumum period of "immunity" at from three to five months, rarely less. There is additional evidence by which we may delimit fairly closely the other extreme, that time at which individuals considered as a group no longer manifest increased resistance to the disease.

The author found that 19.17 per cent. of his population contracted influenza in 1918, and 9.55 per cent. contracted the disease in 1920. Two hundred and forty individuals, or 2.4 per cent. of the entire population developed the disease in both epidemics. Out of 1,971 individuals having the disease in the 1918 spread, 240, or 12.1 per cent. recurred in 1920. This is to be compared with the total 1920 incidence of 9.55 per cent. More correctly we should separate the 1920 cases into two groups, those who had and who had not had influenza previously. The former group, 240 individuals, constitute as just stated, 12.1 per cent. of all who had had the disease previously. The second group, 715 individuals, constitute 8.9 per cent. of the 8,034 who had not had the disease in 1918–19.

From these results we must conclude that *a previous attack contracted on an average of from* 10 *to* 17 *months before, conferred no protection whatever against a second attack. On the contrary, the attack rate was slightly higher in this group than in those who had not previously had the disease.*

Yet another evidence of the insignificant part played by any immunity in the occurrence of influenza in individuals in 1920 is indicated by our series of 319 infants living in 1920 but who had not been born during the 1918 spread and who were presumably not immune to the disease. We have not investigated whether the mothers had had the disease in 1918. From among these 319 infants, thirty or 10 per cent., developed the disease in 1920. This is practically the same percentage as for the population at large.

These findings also correspond with our previously recorded conclusion made after studying the disease incidence with three increasing degrees of exposure, *sleep*, *room* and *family* (page 198).

TABLE IX.

Comparison of the severity of the first and second attacks in individuals contracting influenza in 1918–19 *and again in* 1920.

Severity.		No. of cases.	Comparison.	No. of cases.
1918–19.	1920.			
Average	Mild	43		
Severe	Mild	50	Second attack milder	132
Severe	Average	39		
Mild	Mild	30		
Average	Average	22	Both of equal severity	72
Severe	Severe	20		
Mild	Average	13	Second more severe	36
Mild	Severe	5		
Average	Severe	18		

Altho we find no conclusive evidence of protection against recur rent attacks, we do find (Table IX) that the second attack in the same individual was usually milder. However, the 1920 epidemic as a whole was milder, (Chart XVIII).

Zinsser quotes a letter from Frost in which the latter states that in Baltimore those persons who were attacked during the 1918–19 epidemic showed no relative immunity during the epidemic of 1920. This is not a contradiction to the earlier Baltimore studies, since in that case the interval between the epidemic waves was not more than about three months.

Jordan and Sharp have obtained statistics regarding approximately 4,000 men at the Great Lakes Naval Training Station. The men's statement regarding previous influenza was accepted whenever the attack was said to have occurred during the influenza period of 1918–1919, *i.e.*, in September, October, November, December, January, February and March. The great majority were reported for the period of September to December. Only a few cases were reported as occurring in March, and perhaps these actually occurred somewhat earlier than the men recalled. A few cases were accepted as influenza when reported as occurring in Europe during July and August, 1918.

They found that 28.5 per cent. of 3,905 men had had the disease in

1918, and that 22.6 per cent. were attacked in 1920. Of those who had the disease in 1918–19, 21.2 per cent. had a repeated attack in 1920, while of those who had not had a previous attack, 23.1 per cent. were attacked in 1920.

A similar study among 2,472 men at Camp Grant showed that 15.8 per cent. had had influenza in 1918–19, and 11.7 per cent. in 1920. Of those with previous influenza history 15.6 per cent. had a repeated attack, while of the remainder without previous history of influenza 10.9 per cent. were attacked in 1920. They conclude that no marked immunity to influenza exists 12 to 15 months after a previous attack, but that the results do not show that some degree of immunity may not obtain at an earlier period.

It is interesting while considering the subject of immunity to pay particular attention to those who *did not* develop the disease as well as to those who did. In our series 70 per cent. of all individuals escaped the disease in both epidemics. With some variation this figure will hold for all communities. Or, again, among those who had the disease in 1920, 75 per cent. *had not had it* in the preceding waves.

Hall states that in Copenhagen at the Bispebjaerg Hospital, among the 500 patients with influenza in the four weeks early in 1920, 91.8 per cent. *had not had* the influenza during the 1918–19 epidemic. H. F. Vaughan found in a review of 2,500 cases occurring in Detroit in January, 1920, that 84 *per cent. had never had* the influenza before. The true significance of these figures cannot be recognized, because we are not informed as to the per cent. of these populations attacked in 1918–19.

We observed such a universal distribution of influenza during the epidemic period that it is frequently assumed that all individuals are exposed to the disease, that the virus must enter the body of all or nearly all, and that it is due chiefly to a relative natural immunity that some do not fall victims. Is this the actual state, or is it true that the distribution of the virus is limited to about one-third of the population and that practically all of those who are actually exposed develop the disease? These are the two extremes; more probably the actual state is somewhere between.

This question cannot be definitely answered, and yet it is one of extreme importance, particularly with regard to prevention and combat of the disease. How universally is the influenza virus distributed during pandemics? What proportion of the population is actually exposed by invasion with the virus? What proportion of actually exposed individuals develops the disease? We will refer to this again

when comparing influenza with other infectious diseases, but it is of particular interest now to review our individuals who were exposed by sleeping with cases of influenza. Fifty-five per cent. of all individuals sleeping in the same bed with cases of influenza in 1918 *did not* contract clinical influenza. Seventy per cent. of all individuals sleeping with influenza cases in 1920 *did not* contract the disease, in recognizable form. Sixty-nine per cent. of all individuals in 1920 who had not had the disease previously and who slept with cases *did not* develop evidences of the disease.

It is difficult to conceive of a degree of exposure much closer than that of sleeping in the same bed with a sick individual. And yet it is equally conceivable that many individuals sleeping in the same bed with a patient were not penetrated by the virus of influenza. This does not aid us in answering our question. We do not know whether the more important factor is that of a natural immunity or that of absence of actual invasion by the virus.

These results with sleeping contacts form an interesting link in the chain of evidence started during 1918 by the U. S. Navy and Public Health Service, and reported by Rosenau and by McCoy and others. These experimenters working in Boston and in San Francisco carried out inoculation experiments on human volunteers. The work in Boston, as reported by Rosenau, was carried on with 100 volunteers from the Navy between the ages of eighteen and thirty, most of them between eighteen and twenty-five; all of them entirely well, and with the exception of a few controls, none having experienced known attacks of influenza previously. First, suspensions of thirteen different strains of influenza bacilli, all from cases of influenza during the epidemic, were sprayed into the nose, eyes and throat of nineteen volunteers. None of them took sick. Next, secretions from the mouth, nose and throat and bronchi of acute cases of influenza were collected, pooled, and without filtration sprayed into each nostril, into the throat during inspiration, and onto the conjunctiva of each of ten volunteers. None of them took sick. Some of this same material was filtered through a porcelain filter and administered in the same manner, with similar results. One cubic centimeter of each type was administered to each individual. The interval between the time of collection and time of inoculation was then decreased to one hour and forty minutes, the minimum time in which the material could be transferred from hospital to experiment station. The same results were obtained. This time six cubic centimeters were administered to each individual. Finally, transfer was made directly with swabs from

the nose, throat and nasopharynx of one individual to another in nineteen cases. None developed the disease.

The next series of experiments consisted in an attempt to inoculate volunteers with influenza by injecting into them 10 cc. of citrated blood, which was the pooled collection from five cases of acute influenza. Ten volunteers were inoculated. None took sick. Next, the secretions from the upper respiratory tract of acute cases were injected subcutaneously into ten volunteers, each receiving 3.5 cc. This material was first put through a porcelain filter. None took ill. In an attempt to reproduce the disease in imitation of nature, ten individuals were exposed to cases of acute influenza in hospital wards. Each volunteer was placed very near to the patient, shook hands with him, talked and chatted with him, for five minutes, after which he received the patient's breath full in his face five times while he inhaled, and finally the patient coughed five times directly into the subject's face. Each volunteer did this with each of ten different patients, all of them acutely ill, none more than three days sick. No volunteers developed the disease. All cases of influenza used throughout the period of these experiments were typical acute cases selected from a distinct focus or outbreak of the disease. Sometimes, for example, they would select four or five typical cases from an epidemic in a school with a hundred cases.

In February, 1919, the experiments were continued at Portsmouth, where the secretions were transferred direct from individual to individual. In about thirty-six hours half of the number came down with streptococcus sore throat, but not with influenza. One of the medical officers, however, who had been very active in the experiments, and who had come into intimate contact with the disease since early in October, but who had not been inoculated, developed, during this experiment, typical influenza. The explanation for these failures is not certain. The experiments were started rather late after the onset of the epidemic, and the volunteers may have developed some immunity, although they had not developed the disease. Or, they may never have been susceptible.

McCoy made a similar series of experiments in San Francisco, using volunteers who so far as known had not even been exposed to the outbreak, also with negative results. However, many of these latter had been "vaccinated against influenza" with a mixed vaccine.

Wahl and his co-workers found that the nasal application of a filtrate from the pneumonic lung of an individual dead with typical influenza-bronchopneumonia failed to call forth any abnormal symp-

toms in human subjects. The application to the mucous membrane of the nares and nasopharynx of five healthy men, who had been inoculated from four to six weeks previously against influenza with a polyvalent influenza vaccine, and of one uninoculated, of freshly prepared suspensions of four different live strains of Bacillus influenzae, even in massive doses failed to produce any abnormal symptoms. The implantation of living suspensions of Bacillus influenzae produced no material alteration besides the addition of the influenza bacillus itself. When experimentally introduced into the nasopharynx of men the influenza bacillus exists and multiplies for a considerable length of time, two weeks or more. It apparently shows much resistance to the action of dichloramin T.

SECTION VI.

Influenza and Other Diseases.

Influenza and tuberculosis.—Following the 1918 and 1920 epidemics of influenza, there has arisen in the literature some controversy regarding the effect, if any, of influenza on tuberculous individuals. This has centered particularly on the question whether tuberculosis produces some degree of immunity to influenza, and whether the latter, on the other hand, predisposes either to the lighting up of a latent tuberculosis, or to a new infection with the tubercle bacillus. Keen observers in the field of tuberculosis who have had apparently equal opportunities to study the effects of the pandemic differ radically in their conclusions.

The first mention of consumption following influenza was made in 1580 by Thomas Short.

After the 1889–1893 epidemics, Leichtenstern recorded that the mortality tables of all countries agree in showing considerable rise in the mortality from pulmonary tuberculosis in influenza periods. The clinicians of that time made the frequent observation that the course of tuberculosis in the lungs is markedly and unfavorably influenced by grip and its pneumonic complications. Latent quiescent cases often became active, and healed and healing foci broke out anew. Afebrile cases were changed to the hectic type and frequently hemoptysis was induced. In London, during the height of the 1889 epidemic, the weekly death reports from phthisis rose to double the average. The increase in death rate during the epidemic period was not limited entirely to tuberculosis, but there was almost a doubling of deaths due to all acute respiratory infections. After the cessation of the

epidemic, however, there was some decrease in the general mortality, as well as in the mortality from respiratory infections. This was especially true of deaths from pulmonary tuberculosis, which decreased to such an extent that the total mortality rate for the year for this disease was little greater than for preceding years.

Similar observations have been made following the 1918 pandemic. Jordan remarks that in New York City in 1918 during the two weeks of maximum epidemic mortality, the deaths reported from pulmonary tuberculosis numbered 430, as compared with 264 for the corresponding weeks of 1917. Vaughan and Palmer found that the deaths from tuberculosis in the army were higher in the autumn of 1918 than in the two previous four months' periods, the death rate rising from 18 per 100,000 during the summer to 46 per 100,000 in the autumn. The rate for the same time of the preceding year had been 15 per 100,000. They assume that the most plausible explanation for this increase in deaths is that dormant and incipient cases introduced into the army during the preceding year had accumulated and possibly were hastened into the acute stage, both by the duties of camp life, and the prevalence of the epidemic of grip and pneumonia. Quite naturally there had been from the time of the first assembling of troops an accumulation of tuberculous individuals, inasmuch as such men were not discharged, but were kept in the army and under Government control and supervision. Sir Arthur Newsholme in reviewing the relationship between influenza and tuberculosis in England concludes that many deaths from tuberculosis are undoubtedly hastened during an influenza epidemic. Abbott wrote of the epidemic of 1889 in Massachusetts that the chief diseases which followed in its train and were intimately associated with it were bronchitis and peumonia, and that phthisis when already existing in the victim of the attack was undoubtedly aggravated, and in many cases a fatal termination was hastened. Baldwin says that influenza is a frequent and important agent in bringing latent tuberculosis to life. "Allowing for mistakes in diagnosis, influenza must be classed as an important exciting cause, if not a true predisposition."

In frank opposition to the foregoing authorities, Fishberg claims that influenza has had no effect whatever on the course of tuberculosis. He says that a large proportion of tuberculous patients under treatment in New York City in 1918–1919 contracted the disease and not a single one succumbed. This appears as rather an inclusive statement. He goes on to say that some were in far advanced stages of the disease, with large cavities in the lungs, and yet they passed through the acute

symptoms and recovered, the tuberculous process then pursuing its course as if no complicating disease had affected them. He believes that the prognosis was, if anything, better in those who suffered from tuberculosis or any other chronic pulmonary disease, such as asthma, bronchitis, emphysema, bronchiectasis, than in those in whom the lungs and bronchi had been apparently in healthy condition. Fishberg observes that, instead of lighting up the tuberculosis, the influenza runs a milder course than when attacking healthy persons, and the old lung lesion remains in about the same condition as could be expected if no complicating process had attacked the patient. He says that authors who have asserted the contrary have based their arguments mainly on the facts first, that many tuberculous patients date the onset of their tuberculosis as concurrent with an attack of influenza; that many patients suffering from phthisis state that ever since an intercurrent attack of influenza the symptoms of tuberculosis have become more pronounced; that the Pfeiffer bacillus has been found quite frequently in the sputum of tuberculous patients, especially that derived from pulmonary cavities; and finally that in some countries it has been noted that during and soon after an epidemic of influenza the mortality from tuberculosis was increased.

He believes that many of the conditions diagnosed as influenza have been no more than ordinary colds, and that the average patient will call any upper respiratory tract infection grip during or around the time of an epidemic. He further believes that a misdiagnosis of tuberculosis is frequently made in influenza convalescents who show some signs of moisture in their lungs which does not clear up for some time, causing doubt in the mind of the examiner, but which is not truly tuberculous in origin. Fishberg cities P. J. Murphy, Hawes, Armstrong, McRae, and Dickinson, as well as Geiber and Schlesinger, in Vienna, and Rickmann and Ladeck in Germany, as having observed the same phenomenon of relative insusceptibility of tuberculous patients and failure of influenza to hasten the progress of tuberculosis. He also calls attention to the low incidence of influenza in tuberculosis sanatoria, but apparently compares this incidence with the incidence for the public at large, and not with that in similar institutions devoted to the care of invalids with diseases other than tuberculosis, or with other institutions in general.

Amberson and Peters, as well as Minor, take sharp exception to the statement of Fishberg, and the former have collected the evidence against Fishberg's view. They first point out that a comparison of the incidence of 5.4 per cent. among hospitalized tuberculous patients at

Chicago cannot be compared with a much higher incidence of the epidemic in the various military camps. As Heiser has pointed out, the mere quartering of men in barracks seems to have a tendency to increase the risk from acute respiratory diseases. Furthermore, the incidence at some sanatoria was low, while at others it was high, nearly as high as for the community at large. In Hawes' report of the epidemic among the Massachusetts sanatoria, Lakeville had escaped entirely, while Rutland which consisted chiefly of ambulatory cases, less easily controlled, had an influenza incidence of 18.3 per cent. among the patients, and 21.3 per cent. among the employees. At Montefiore Home, the proportion of tuberculous patients and employees contracting the infection was practically the same as among the non-tuberculous employees, and about the same percentage of both groups developed evidence of bronchopneumonia.

Still another fallacy in the comparison of incidence in institutions and the like is proven by the work done by Jordan, Reed and Fink, who found that in the various Chicago telephone exchanges the attack rate varied from five per cent. to twenty-seven per cent., although the working conditions were approximately the same. The attack rate in one section of the students' army training corps in Chicago was 3.9 per cent., while in another section particularly exposed to infection it was 39.8 per cent. Similarly Frost found the incidence in Louisville, Kentucky, to be 15 per cent., and in San Antonio, Texas, 53.3 per cent. All these figures show the difficulty of comparing rates for various institutions and various groups of individuals. Although Fishberg quoted Rickmann in support of his contention that influenza has no effect whatever upon tuberculosis, Amberson and Peters used his work in support of their contention, and call attention to the fact that in thirty out of forty tuberculous persons reported by him who had contracted the grip, the attack did not produce any aggravation of the lung condition. Presumably it did in the other ten. If even 25 per cent. of tuberculous patients who contract influenza have their pulmonary condition aggravated, this should be regarded as a notable number. According to Stivelman, 11.4 per cent. of tuberculous influenza cases died at Montefiore Home. In a survey of convalescents from the Loomis Sanatorium, Amberson and Peters found that seventy had contracted influenza, or 5.7 per cent. of the number surveyed, and that 11.4 per cent. of these had had relapses of their pulmonary condition, apparently due to the acute disease, while 22.9 per cent. had died from the intercurrent infection. 2.8 per cent. were deaths due to tuberculosis after convalescence from the influenza.

Tubercle bacilli have been found in the sputa of convalescent grip patients, whose sputa had previously been negative, by Amberson and Peters, as well as by Berghoff, at Camp Grant. The latter found that 50 per cent. of his cases showed a reactivation and a positive sputum after an attack of influenza.

Amberson and Peters agree with Fishberg in the observation that there has been no increase in the general mortality from tuberculosis within the recent months, and suggest as an explanation the possibility that during the epidemic enough of the old cases were carried off to account for a temporary lull until new cases developed, or others had time to reach later stages of the disease. As we have previously remarked, Leichtenstern observed this same phenomenon following the 1889–1890 epidemic.

The state of our knowledge of influenza and tuberculosis is considerably clouded by divergent opinions such as those quoted above. To further complicate the picture, there are other authors who assume a middle ground and believe that there is some truth in both lines of contention. Thus, Amelung believes that the morbidity among patients with pulmonary tuberculosis is slight, and that the grip takes a milder course in such patients than in the non-tuberculous, unless the disease is far advanced, but that pulmonary tuberculosis may and sometimes does follow the disease in patients whose lungs were previously sound, and that in the last mentioned cases the prognosis is relatively bad. Peck finds that in some tuberculous patients the disease has been aggravated, but in the majority the intercurrent influenza did not appear to have been the causative factor in the acute exacerbation of the tuberculosis.

Debré and Jacquet have reviewed the European literature on the subject pro and con, and though they admit that there are exceptions, as at l'hôpital Tenon, where, in a barracks reserved entirely for female tuberculosis patients there was a veritable epidemic of grip, 29 per cent. of the twenty-eight being attacked in a few days; and at the sanatorium de La Tronche, where 83 per cent. took ill between the 25th of September and the 20th of October; they conclude that as a rule tuberculous individuals are less heavily attacked by the influenza than are the nontuberculous. As they suggest, the first explanation that comes to mind is that the tuberculous are isolated in the hospitals where general hygienic conditions are good, but we have all seen other institutions, hospitals, etc., in which the inmates were not spared as they were in tuberculosis hospitals. Furthermore, in certain sanatoria, such as the sanatorium of the Côte Saint-André, and Bligny, and several

German sanatoria, the proportion of tuberculous individuals attacked was very much less than that of the professional attendants, the physicians and nurses. Again, where cases have occurred in these hospitals, and little precaution was taken to prevent its spread, very few other individuals took sick. Finally, many have noted the infrequency of the disease even in those tuberculous individuals who were living at home. It has been suggested that rest in bed from the beginning of the attack explained the mildness, or that the immunity resulting from the infection with pneumococcus, streptococcus, etc., in tuberculous individuals explained the absence of pulmonary complications. Marfan, who observed this same phenomenon in 1890, suggested that it might be due to a refractory state of the tubercle bacillus against the virus of influenza. Debré and Jacquet conclude that none of these explanations is satisfactory.

Having concluded that tuberculosis does protect in some measure against influenza, Debré and Jacquet next discuss whether the latter has increased the severity of tuberculosis in the subjects who were already tuberculous. They review the literature and make their conclusions, not from statistical records, but from general observations. They consider first those cases of phthisis which are open cases when attacked, and second, latent tuberculosis. Their conclusion concerning the first group is that influenza does not have any effect on the rapidity of evolution of the tuberculous process, except in very rare instances, such as an occasional case of miliary tuberculosis following grip. As regards latent tuberculosis, however, they do believe that the intercurrent acute infection does cause in many cases a lighting up of a previously entirely dormant tuberculosis. It seems rather difficult to reconcile the two ideas. If one type of tuberculous individual is rendered more susceptible to the ravages of consumption, it would seem reasonable to expect that all types would be so affected.

The greatest difficulty in reaching a conclusion regarding the effects of influenza on tuberculosis, and vice versa, is due to the fact that the individuals studied are in all stages of the disease, and that each individual reacts differently and in his own way. Opinions have been based chiefly on clinical observations, and not on statistical study of large series of cases, while from the nature of the conditions, even statistical studies would not be without great fallacy.

Armstrong, found in a survey made in Framingham, Massachusetts, that 16 per cent. of the entire population was affected with influenza, but only 4 per cent. of the tuberculous group in the community. Most of these latter were of the arrested type and were going about

taking their part in industry and exposed to the same degree of contact as was the case with the normal population. The fatality rate was equally in contrast. Armstrong concluded that there appeared to be a relative degree of protection for the highly tubercularized. If we accept these figures at their face value we must conclude then either that tuberculosis offers some degree of protection against acute influenzal infection, or, that the tuberculous of Framingham have been so well trained in sanitation and personal hygiene, as a result of the Framingham demonstration, that they have been able to protect themselves against the grip. In the latter case we must look upon the result as a successful demonstration of the principles of preventive medicine. Certainly this did play a part, to the extent at least that individuals knowing themselves to be infected with tuberculosis, and knowing themselves to be in the presence of a pandemic, became more wary of crowd contact, and in case they did become ill, they undoubtedly went to bed at the earliest opportunity.

If, on the other hand, this is a true demonstration of relative immunity in a chronically infected individual, the explanation must be sought elsewhere. Does a chronic respiratory infection confer a relative degree of immunity to an acute respiratory disease? Do the germs already on the premises exert, so to speak, "squatters' rights?" Are we observing an example of non-specific immunity due to local preceding infection? Still another factor may play an important role, the factor of race stock. The excess of tuberculosis in negroes, for instance, over that in whites, is in some localities double or treble, while various observers, as Frost, Brewer, and Fränkel and Dublin, report that the influenza incidence and mortality among negroes was decidedly less than that among the whites. Winslow and Rogers found that in Connecticut the proportion of influenza-pneumonia deaths is lower than would be expected among persons of native Irish, English and German stock, and higher than was to be expected among Russian, Austrian, Canadian and Polish stock, whiel it was enormously high among the Italian. Italians are notably insusceptible to tuberculosis, while the Irish are much more prone to infection with the disease. For example, in Framingham, where the tuberculosis incidence rate for the entire population was 2.16 per cent., the rate in the Italian race stock was 0.58 per cent., and in the Irish, 4.80 per cent. In Framingham there was about four times as much influenza among the Italians as among the Irish. Is this apparent insusceptibility of certain race stocks an inherent condition, or is it dependent chiefly on differences in living conditions and in age pre-

valence in the different races? Probably it is chiefly the former. Frost, for instance, found that among the negroes the incidence of influenza was lower even though the living conditions were much poorer than those among the whites.

Armstrong's survey has also thrown some light on the effect of the influenza on previously tuberculized individuals. In a survey of 700 individuals who had had the acute disease there were ten arrested cases of tuberculosis, or 1.4 per cent. All these had been known to be arrested cases previous to the epidemic, and in none of them did the disease appear to have been actively and permanently lighted up. Some had manifested a slight activity, but all seemed to be on the way to a rearrest of the disease. On the other hand, thirteen cases, or 2 per cent. of the 700, were found to have active tuberculosis which had hitherto been undiagnosed, and an additional eight cases, with indefinite broncho-pulmonary signs, were designated as incipient tuberculosis cases. This is to be contrasted with an incidence of active tuberculosis in the pre-epidemic examination of approximately one per cent. These figures would indicate an increase in tuberculosis incidence. How may this be explained? The acuracy of these results will depend on how the 700 cases were selected. If, for example, individuals who feared tuberculosis because of known exposure, requested examination, the results might be influenced by their inclusion.

It has long been known that individuals with measles will not react to tuberculin tests, even though they have been positive before developing the measles, and though they will become positive again after recovery. The same may be said of vaccination. Individuals vaccinated against smallpox, who have measles, and are during their illness revaccinated, will not show an immediate reaction. The test will remain entirely negative, while after recovery, the immediate reaction may be obtained. Normally, it will appear in 95 per cent. of cases, while among those with measles the phenomenon remains absent in 90 per cent. The same phenomenon is present in certain other acute illnesses, particularly scarlet fever. It has been variously explained. von Pirquet, who was the first to observe it in measles, believed that the acute disease created a temporary inability to produce antibodies, and therefore designated the condition by the name "anergie." The same phenomenon of anergie has been found recently to hold in the case of influenza. Debré and Jacquet, Lereboullet, Bloomfield and Mateer, as well as Berliner and Schiffer, have brought forth abundant evidence to this effect, following the 1918 pandemic. It has also been shown by Cayrel and others that there is

a diminution of typhoid agglutinins in the serum of influenza patients vaccinated against typhoid. The agglutinin titer again increases after recovery. It is true that the agglutinin titer is not a measure of immunity, but it is frequently used as such and serves to give us some information on the subject. If, then, influenza is an anergic disease, a "maladie anergisante," we have a theoretical explanation of the increase in severity of tuberculosis following the acute infection. We have long observed that tuberculosis frequently follows measles. We have recently been thoroughly convinced that influenza lessens resistance to secondary infection with streptococcus, pneumococcus, and other respiratory tract organisms. Shall the tubercle bacillus be added to this list? During the 1918 epidemic we saw men in the army camps who passed through an attack of influenza-pneumonia and died within a few weeks from tuberculous pneumonia or miliary tuberculosis. These men had previously been so free from signs of their tuberculosis, as to be accepted for military service as healthy individuals. The number of these cases was small, to be sure, but sufficiently large to convince us that there do exist instances in which tuberculosis is tremendously fired by an intercurrent influenza.

If we may judge merely by the balance of evidence and risk any conclusions from such conflicting testimony, we may sum up as follows:

1. Great variation in the interaction of tuberculosis and influenza must be expected, because of the many stages at which the tuberculous may be attacked, because of the altered mode of living of known consumptives, and because of the protected life of most of them.

2. Phthisical patients as a group, may be *relatively* insusceptible to influenza infection. This may be due to the tuberculous process itself or to some extrinsic, but nearly related cause.

3. But many individuals with pulmonary tuberculosis *do* get influenza.

4. And the disease, having been contracted, in many cases hastens the fatal termination of the tuberculous process.

5. It may be that this phthisical exacerbation occurs more frequently in individuals with latent tuberculosis, individuals who are not at the time mobilizing their protective antibodies.

Other infectious diseases.—We have found diversity of opinion regarding the relationship between influenza and tuberculosis, and yet the latter, being as a rule very chronic and presenting very definite signs which may easily be followed, should theoretically be a disease in which the results of study would be quite definite. When it comes to a study of other maladies we find the same difference of opinion frequently present.

It has been the experience of many that during influenza epidemics other acute specific infectious diseases appear to diminish, both in number of cases and in extent. At Camp Sevier, for example, two measles wards had been quite constantly full of patients up to the time of the fall influenza epidemic, while during the time of the epidemic one ward appeared sufficient to hold all cases of measles. In the stress of the epidemic this difference was probably more apparent than real, and certainly is not to be taken as of statistical value.

Vaughan and Palmer report for all troops in the United States that, "Without exaggeration it may be said that for the time being at least, influenza and pneumonia suppressed other infectious diseases. Typhoid fever increased to a barely noticeable degree. The death rate from this disease was somewhat higher, but the total number is so small as to barely warrant comment, and not to justify any definite conclusion. Scarlet fever and malaria were both lower than during the summer. In fact, there was but one scarlet fever outbreak of any importance and that occurred at Camp Hancock. Within two weeks over 300 cases were reported and this marks the largest scarlet fever epidemic that occurred in the camps in this country at any time. Meningitis increased although it did not reach the prevalence of the previous winter. The weekly incidence curve for all troops in this country suggests that meningitis was in some instances a sequel to influenza. The greatest meningitis incidence corresponds with the influenza peak. Diphtheria showed no material increase. Deaths from tuberculosis were higher in the autumn than in the two previous periods, the death rate rising from 18 per 100,000 during the summer to 46 in the autumn. The rate for the previous winter was 15."

In 1889 Abbott was unable to find satisfactory evidence of a connection between influenza and other epidemic diseases, although as he mentions, such connection had often been affirmed. Instances in support of each position were to be found in the literature of the time.

P. Friedrich, after an exhaustive study of the literature, following the 1889 pandemic, concluded that there was no relationship whatever between the incidence of influenza and other acute infections. Wutzdorff reached the same view after studying the various diseases during the influenza recrudescences and recurrences. Finally, Ripperger concluded likewise.

It may be remarked that following 1918 there have been several articles written concerning the relationship between influenza and certain other diseases. These are difficult to correlate and in most instances so many additional factors play a part that the conclusions

drawn are perhaps not entirely well grounded. Sylvestri found that in his experience malaria patients escaped the influenza during the pandemic. He believes that it was the malaria rather than the quinine which was responsible for the apparent immunity. On the contrary others have observed, if anything, an increase in malarial patients.

Fränkel and Dublin found that during the pandemic period deaths from whooping cough increased. The difficulty of differentiating between whooping cough and influenza as a cause of death is apparent.

It seems quite certain that deaths from organic diseases of the heart increase during and following influenza epidemics and are due probably to the inability of the weakened patients to resist the added burden. Fränkel and Dublin found an increase in deaths from this cause. This was also observed to be true in Spain and other localities.

Jordan has compared the curves of influenza with those of acute coryza among school children of Chicago and finds that the period of highest incidence of colds in October, 1918, occurred in the second week of school and that it preceded the corresponding period of influenza by seven weeks. There were three peaks in the curve for colds and only two in that for influenza. The period of highest incidence of colds follows the first peak of the influenza curve by one week, while during the week of greatest prevalence of influenza there is a sharp fall of the number of cases of colds. The third peak for colds occurred one week after the height of the influenza curve. As a rule the colds curve runs at a higher level than that for influenza. A striking fact is that the portion of the curve for influenza contained within the period November 23d to December 7th, is almost the exact opposite of the corresponding portion in the curve for colds. How much of this is due to the factor of diagnosis is difficult to say.

Encephalitis lethargica.—It is not within the scope of our report to discuss in detail this disease. Its apparent relationship with influenza, in point of time, if not otherwise, calls for special mention. In 1712 a disease followed a pandemic of influenza, occurring particularly in Germany, where it was known under the name of "Tübingen Sleeping Sickness." In the spring of 1890, according to Netter, a disease of similar character called "Nona" was distributed especially in Northern Italy and Hungary and scattered more or less diffusely over a large part of Europe. Preceding the last influenza pandemic the disease was first reported in Vienna in the winter of 1916–17. Cases were seen in Paris in February and March, 1918, and the first official report of the disease in England seems to have been on January 26, 1918. In the spring of 1918 there were 168 officially reported cases in England

with 37 deaths. The disease seems to have disappeared there in June, 1918, and reappeared in the autumn of the same year. The first cases in the United States were reported by Pothier at Camp Lee, Va. Following the great influenza pandemic cases of lethargic encephalitis have appeared in all parts of the world. It has been present in England, France, Belgium, Switzerland, Austria, Greece, Italy, and other countries of Europe, South America, Mexico, the United States, Australia, Queensland, New South Wales, and Algiers. There was an increase of encephalitis lethargica concomitant with the increase of influenza in the early months of 1920. Thus, in Switzerland 440 cases were reported during February, 1920. The 1920 epidemic of influenza in that country had almost ceased by the middle of March, while that of lethargic encephalitis had greatly decreased. One hundred and forty-one cases of the latter disease appeared in the canton of Zürich alone.

Is epidemic encephalitis a disease sui generis or is it a form of influenza?

The consensus of opinion has been that it is a separate disease. There is, however, no way of telling how close is the relationship to the influenza itself. If lethargic encephalitis is a sequel to influenza, is it caused by the same germ? Flexner points out that in 1916, when the first cases of encephalitis appeared or at least were recognized in Austria, the epidemic of influenza had not yet appeared. In England, France and the United States the epidemics of the two diseases were more or less coincidental. He believes that little weight can be given the supposed coincidence of influenza and the "sleeping sickness" of 1712, and that it is highly improbable that the semi-mysterious affection, "nona," which dates from 1890 was definitely a sequel of influenza. He concludes that the outbreak of encephalitis either antedated the pandemic of influenza of 1918, or that the two diseases more or less overlapped; that is, although probably quite by accident, they prevailed concurrently. He prefers for the time being at least to regard them as independent diseases.

Crookshank believes that encephalitis lethargica is a distinct disease, but that it occurs frequently as an antecedent of or co-incident with influenza, together with increase in the existence of poliomyelitis and certain other diseases.

Nevertheless the association in point of time and place between influenza and lethargic encephalitis cannot be lightly overlooked. As we have seen, Flexner's criticism that encephalitis antedated the influenza is not valid, because the latter was present in 1916. We must await fuller evidence on this subject.

SECTION VII.

Comparison of Influenza with Other Epidemic Diseases.

A certain amount of knowledge concerning the epidemiology of influenza may be gained by a comparison of the epidemic features of that disease with those of other epidemic diseases, particularly measles and the exanthemata, meningitis, the plague, and certain diseases of the lower animals. Influenza is described as a disease with distinctive epidemiologic characteristics, the chief of which are found only in epidemic spreads. Thus one of the fundamental characteristics of these epidemics is supposed to be the primary type of wave, the wave characterized by rapid rise, quasi-symmetrical evolution, and a concentration closely grouped around the maximum. "This is found in no other disease. In no other type of epidemic does the curve rise as rapidly to a peak or fall as swiftly, nor is the epidemic completed in as short a time."

The secondary type of curve, that which is more frequently found in recurring influenza epidemics, characterized by a more gradual ascent, a still more gradual decline and a longer duration, is found frequently in the curves for other diseases; it is much less characteristic. We shall attempt by a comparison of epidemic influenza with these other diseases to explain the cause for this characteristic primary curve, so as to gain a further insight into the epidemic features of the disease.

There are certain characteristics held by epidemic influenza in common with other diseases. There are certain resemblances between it and epidemic meningitis; in certain ways it resembles measles and there are some points of similarity to the pneumonic form of plague. The fact that it cannot be compared with one of these diseases to the exclusion of the others renders deductions more complicated.

Epizootics.—Soper has written at some length on a comparison of influenza in man with the so-called influenza among horses. The close resemblance in many features is striking.

Epizootics of a disease apparently resembling influenza have been described among horses from before the Christian Era. A disease believed to have been influenza was recorded as having occurred B.C. among horses in Sicily. According to Parkes the epidemic which attacked the army of Charlemagne in 876 attacked at the same time dogs and birds. Finkler describes an epizootic among horses in 1404 A.D. There were other epizootics in 1301, 1711 and 1870 to 1873. In 1901 a severe outbreak occurred in America, and one has

also been described by Mathers as occurring in Chicago in the winter of 1915–16. These epidemics of a disease clinically resembling influenza have frequently occurred among horses at the same time with true epidemics of influenza in man. Nevertheless there has been no clear cut evidence to prove that the disease is the same.

Leichtenstern discusses the incidence of respiratory disease among animals, particularly household pets during epidemics of influenza. He comes to the conclusion that human influenza is a disease limited entirely to the human race and having no connection with animal disease. This is particularly true with regard to diseases reported among cats, dogs, canaries and other captive birds. He also believes that the epizootics among horses which have been reported from time to time as occurring with influenza epidemics have nothing to do with the disease in man. The symptoms are frequently very similar, but epizootics have frequently occurred at times when there was no epidemic of disease among humans.

Abbott concluded that during the great horse epidemic of 1872 which bore a strong resemblance to influenza the disease was not unusually prevalent among men except in a few limited localities; while other infectious diseses, such as measles, small pox, scarlet fever and cholera infantum were unusually prevalent in that year.

Soper writes that, "Economically, influenza is the most important disease of horses in temperate climates. The mortality among remounts has been many times greater from influenza than from all other diseases put together. It is estimated that over 25,000 horses purchased by the British Government in America and Canada, during two years of the war, died in those countries while awaiting shipment to Europe. In a circular issued January 12, 1918, by the Surgeon General of the United States Army to the veterinarians of remount depots, it was stated that the losses from influenza among American army horses amounted to over $100,000 a week. The disease spoken of as influenza in the horse has many other names. It is commonly called pink-eye, shipping fever, stable pneumonia and bronchitis. By some influenza is not believed to be a single disease, but a group of diseases. By others it is considered to be a definite entity, varying in its symptom complex at different times and with various horses. Infectious laryngitis and infectious pharyngitis seem to be independent diseases. Two forms of influenza are generally distinguished: catarrhal and pectoral."

Even after the last pandemic of influenza the question has again arisen as to the identity of the disease among animals. Orticoni and

his co-workers observe that there was an extensive epizootic among horses at the time of the 1918 epidemic in the area which they had under observation. There have been other similar reports. The popular press, during the height of the 1918 spread, reported that there was a highly fatal influenza infesting the monkeys of South Africa and that the baboons were dying in scores, their dead bodies being found on the roadsides and in the vicinity of homesteads. Another report tells of the influenza decimating the big game in Canada, and yet another tells of the havoc wrought among the buffalos and other animals in the United States National Parks. These reports have not been corroborated by scientific observations.

Soper has analyzed the subject of so-called influenza among horses. He finds that the disease is quite generally distributed, that it has many points of close similarity to the influenza of man, but that it is a distinct and separate disease. The two diseases are not identical and neither can be transmuted into the other.

"Briefly, the symptoms, as stated in a recent publication of the United States Department of Agriculture, are sudden onset; fever in some cases preceded by chill; great physical prostration and depression of nervous force; sometimes injected mucous membranes, especially those of the eye, and loss of appetite. In uncomplicated cases the fever abates after about a week and there is a general restoration to health. Pneumonia is one of the frequent complications and is always serious. The death rate varies between two and seven per cent. The most usual form is the catarrhal type. The attack may last only two or three days; in other cases the course may extend to two weeks, in which event it takes the animal a long time to get well. Horses which have passed through this form of disease may be considered to have recovered two weeks after the disappearance of the fever.

"The diagnosis of influenza depends as much upon its epidemiological aspects as upon the symptoms. Law bases it on the suddenness of the attack, its epizootic character, the numbers attacked in rapid succession and over a large area as compared with ordinary contagious pneumonia, the sudden and extreme prostration, the mildness of the average case, the congestion of the upper air passages, the watering and discoloration of the eyes, and the history of the case. Points of interest in the history are the arrival of the infected horses within a few days from an infected place, or coming through such a place, or the attacking of new arrivals in a previously infected stable, or the known advance of the disease toward the place where the patients are located."

Soper found that the progress of the epidemic of 1872–73 among the horses in this country was as generalized, but much slower than the progress of the recent pandemic among human beings, the rapidity of progress corresponding with the rapidity of the transport of the horses at that time. Just as we have found in the case of influenza so also at that time the spread only followed lines of communication and actual contact between horses.

It is highly interesting that attempts to transfer the disease from horse to horse experimentally met with the same degree of failure that was experienced in similar attempts to transfer influenza experimentally from man to man. In fact Lieut. Col. Watkins Pitchford of the British Army Veterinary Corps in a report in July, 1917, stated that it was impossible to produce infection experimentally. Nose bags were kept upon horses with profuse nasal discharges and high temperature, and these nose bags were then used to contain the food of other horses without infection taking place.

There are several other points of resemblance between horse influenza and human influenza. The mortality from influenza among horses is under ordinary circumstances between two and seven per cent., and is highest in horses worn out by fatigue after a long railroad journey, among fat horses out of condition, and among horses which have been driven after they were sick. The death rate in the simple catarrhal form of influenza rarely exceeds one-half of one per cent. while in the pectoral form it is never less than four or five per cent. and may reach 16 per cent. The only measure of prevention which has been found wholly satisfactory is strict isolation. Usually influenza occurs in horses who have newly arrived in a stable from elsewhere. Practically all the newly arrived horses and country horses are almost alone susceptible. Soper, who has studied the records, such as they are, in the army veterinary corps, and also the records from the Bureau of Animal Industry, concludes that they show nothing to indicate that any general epizootic of influenza occurred among horses during the year 1918 corresponding to, or connectable with the pandemic of influenza among human beings. There was influenza among the horses, but he does not think it was extensive enough to be allied with influenza among human beings. He concludes that there are two types of influenza among horses, first a mild form which nearly all horses get when transferred to a contaminated stable, after which there develops immunity, and the second type, a true epizootic which may sweep the entire country, attacking practically every horse. A most suggestive result of his study lies in the fact that

predisposing influences play a most important part in the production of serious influenza among horses.

Aside from noting a certain similarity between the epizootic of so-called influenza in horses and influenza as we know it in man, we cannot acquire much additional information concerning influenza itself from a consideration of this subject. The important conclusion is that in several of the most important epidemiologic features the two diseases are similar and that the study of human influenza may be furthered by critical studies of influenza in horses. We shall attempt to demonstrate that influenza in a similar manner is not unlike other epidemic diseases.

Asiatic cholera.—There are those who claim that the disease should be compared with Asiatic cholera which remains constantly endemic on the banks of the Ganges and at intervals spreads from there throughout Indo-China, and formerly at times throughout the civilized world. Those who compare influenza with this disease believe that this is additional evidence in favor of a single focus of endemicity of influenza.

Epidemic meningitis.—On the contrary the disease may well be compared with epidemic meningitis. The germ of this disease, distributed throughout the world, is usually in an avirulent form and produces no epidemic of meningitis. Only an occasional case arises. There are certain localities in which the disease is particularly prevalent at all times. We may speak of these as endemic foci, but must remember that at the same time the virus is distributed elsewhere. Thus South Carolina, Missouri and Kansas have been shown to be localities in which meningitis has been more or less widely distributed for some years.

We can carry the analogy still farther. During the concentration of forces early in the war, camps were established at Columbia, S. C. and at Fort Riley, Kansas. In these camps, Jackson and Funston, there very rapidly developed quite extensive epidemics of cerebrospinal meningitis. Here and in Camp Beauregard, the incidence of the disease was out of all proportion to that in the other camps. Just as the exaltation of virulence of the influenza virus has been favored by gross changes in the environment, the occupation, the density of, and the disease incidence in the host as a community, so also do these appear to have been factors in the development of a meningitis prevalence in the army. It was more prevalent in those camps situated in the territories where the disease was particularly endemic, but was also present in all camps. Had the meningococcus been able to assume the high degree of virulence and invasiveness possessed by the influenza virus it is reasonable to assume that a pandemic spread would have

begun in one of the two or three camps where the disease was especially prevalent. It would have spread thence and have attacked those camps in which a mildly virulent meningococcus had already been causing disease. Just as in influenza the pandemic spread would have been due not to the universally distributed virus, but to the one or few which finally acquired the greatest exaltation of virulence.

We see then that the followers of both theories—that of the single focus and that of an extensive distribution—can quote other infectious diseases in support of their theory, but the evidence in favor of similarity to Asiatic cholera is not complete. The disease is not similar. The mode of transmission is entirely different. The infection is chiefly of the gastro-intestinal tract, while that in influenza is chiefly respiratory. Since 1816 there have been five pandemics of Asiatic cholera, the last occurring in 1883 and all of them traceable to a primary focus in India. Frequently it was carried from India by the faithful, to Mecca and from there was readily distributed throughout Europe. In the last pandemic the disease spread throughout the old world and reached New York harbor, but was refused admission.

Plague.—The similarity in clinical symptomatology, in gross pathology and the apparent similarity in manner of spread and epidemic features between influenza and the pneumonic form of plague has suggested to some that the best comparison should be made with the latter disease. Here again is a disease which is endemic in Asia and spreads elsewhere only at intervals. If we go back into the history of the plague we will discover that formerly it was distributed more or less throughout the civilized world. The plague is supposed to have been known to the children of Israel at the time of the exodus from Egypt. The Egypt of the Pharaohs was a country of great salubrity. Hygienic measures were excellent. The inhabitants built aqueducts, disposed of their dead hygienically, reared temples, maintained law and order, developed the elements of literature and science and devised and employed simple machinery. But as early as the exodus, Egypt had lost its salubrity. This is indicated by many passages in the Bible. The plague was present in that country during this period. Sticker believes that the pest among the Philistines spoken of in the First Book of Samuel, when the captured army was returned with five golden emerods and five golden mice, was the bubonic plague.

Thucydides describes a plague in Athens occurring before Christ. This is generally believed to have been "the plague." The time of the earliest appearance of the disease in Italy is not known but it was well established there in the first century of our era. The plague was endemic in Italy at that time and it developed in epidemic form with each

increase in susceptible material. At about 68 A.D. the disease spread over the whole of Asia, Northern Africa and Europe. Exacerbations of the disease are described in the years 80, 88 and 92 A.D. In Rome they occurred in 102, 107 and 117 A.D. The disease was present in Wales in 114 A.D. In 167 an unusually severe outbreak of the plague occurred in Rome. There were other outbreaks in the Roman army in 173, 175 and 178. Had we the space to record here the history of the plague we would find that the disease was widely distributed throughout Europe for several hundreds of years, that it was particularly prevalent in certain areas and that at intervals it spread from one or a few foci, throughout the continent.

We can compare the epidemic features of influenza with these other contagious diseases, but we will always find some points of difference from one or another. Let us consider again for a moment epidemic meningitis. There is no combination of predisposing causes, environmental, meteorologic or bacteriologic which will produce epidemics of cerebrospinal meningitis in the absence of the meningococcus itself. The organism causing the disease must be present before the disease will occur. The specificity of the invading organism in the different diseases will always produce some variation among the epidemiologic features. Other things being equal, that locality in which this germ is most extensively distributed will be the locality in which epidemics, when they do break out, will be most entensive.

In the case of our army camps, those individuals carrying the disease virus from the endemic foci to the camps were not the ones who fell ill. Generally it was those, coming from other areas in which meningitis was not extensively distributed and who had, therefore, not acquired an increased resistance to the disease, who fell ill. But after the disease had acquired increased virulence at Camp Jackson, not only did it occur in the troops at that camp, but it also became quite extensive throughout the civilian population, presumably among those who had previously been exposed to it in its endemic form.

In our comparison of influenza with other infectious diseases we wish to show particularly that the disease is not in a class by itself, but that its epidemiologic features are not unlike those of other respiratory infections, that the manner of spread and the mode of infection are similar to those of the other diseases. Nothing unusual or unknown need be called into use in explaining any differences. Those differences that very palpably exist can be explained by facts which we already know. Leichtenstern, thirty years ago, believed that the disease was similar in its manner of spread to other infectious diseases.

He observed this particularly in the earliest and the latest phases of epidemic spreads where cases were scattered. He saw that in households the disease attacked some and spared others even of those intimately connected with the sick, just as was the case in diphtheria or meningitis. He writes: "Comparing these later periods the disease evidences the same contagious characteristics as the other endemic contagious diseases, such as scarlet fever, measles, diphtheria, epidemic cerebrospinal meningitis, etc."

Parkes made very similar observations even before the 1889 epidemic.

Measles.—A comparison of influenza and measles will offer some explanation of the differences between the epidemic constitution of the former and that of the other respiratory diseases.

We are accustomed to think of measles as a disease which, like meningitis, is disseminated throughout the civilized world, and which although constantly with us causes only sporadic cases. True epidemics of measles do occur, even when there is no gross change in the constitution of the population. We have discussed examples of this particularly in London. Flare-ups of measles prevalence are in fact so much the rule that in certain localities health officers anticipate a measles epidemic about once in two years. Furthermore measles has been known more than once to occur in extensive epidemic form, attacking large proportions of the population invaded. We know that there is an immunity to measles which is nearly absolute in those who have once acquired the disease. The epidemics have, therefore, occurred exclusively in those localities where the proportion of immune individuals was relatively small. According to Noah Webster in 1772 measles appeared in all parts of America and was accompanied by an unusually high mortality. In Charleston 800 or 900 children died of the disease. The following year measles "finished its course and was followed by a disorder of the throat."

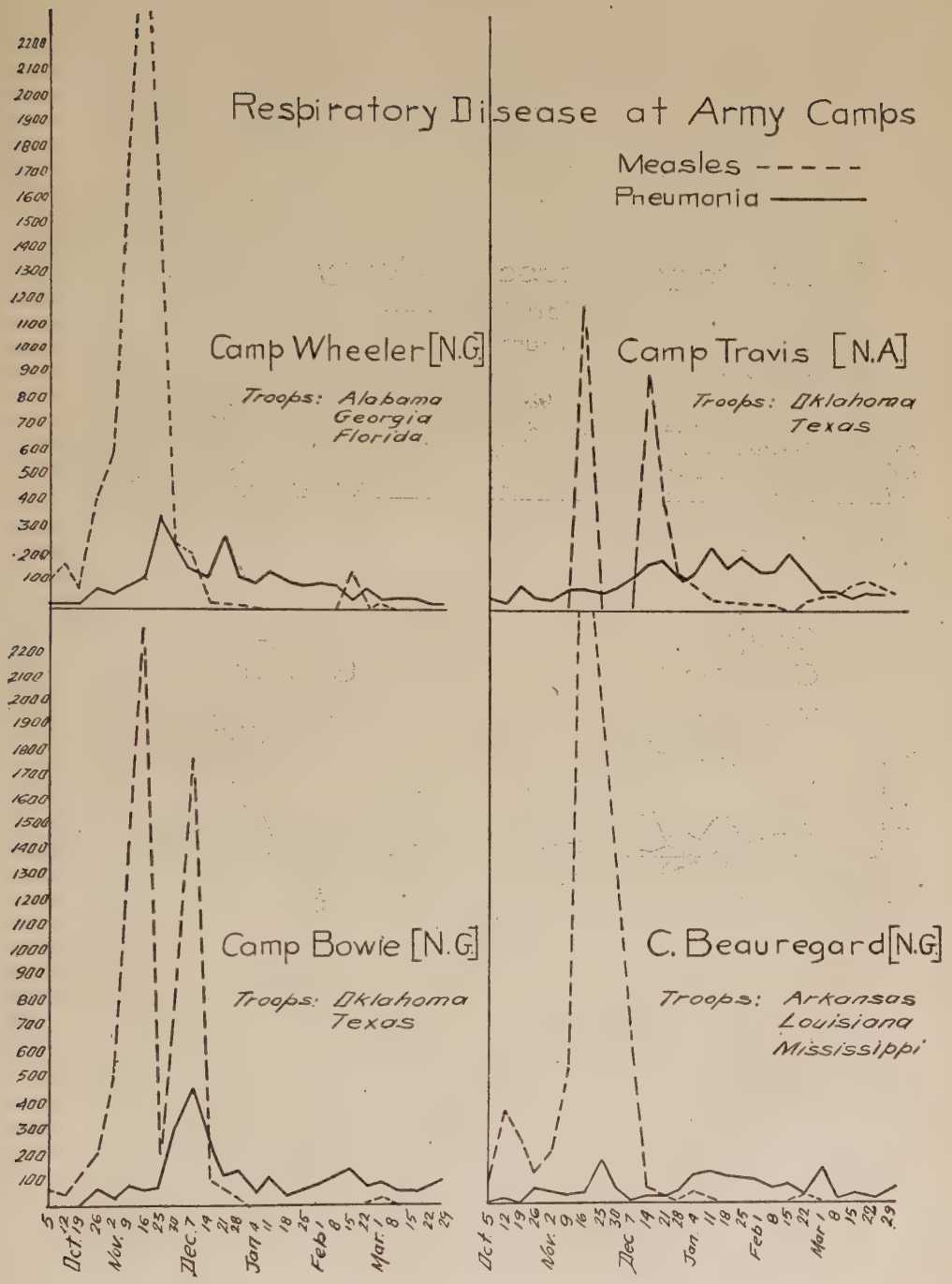
In 1781 measles disappeared from the Faroe Islands, and for the following sixty-five years there was not a case of this disease anywhere on any of the seventeen islands constituting the inhabited parts of this group. When the disease was finally re-introduced into these islands, it spread throughout the population, attacking practically every individual in a relatively short interval of time, showing a much higher attack rate than did influenza in 1918. There was this difference, that the only individuals who did not acquire measles on its re-introduction into the islands were those who had had it sixty-five years before. Panum did not find an authentic case of recurrence

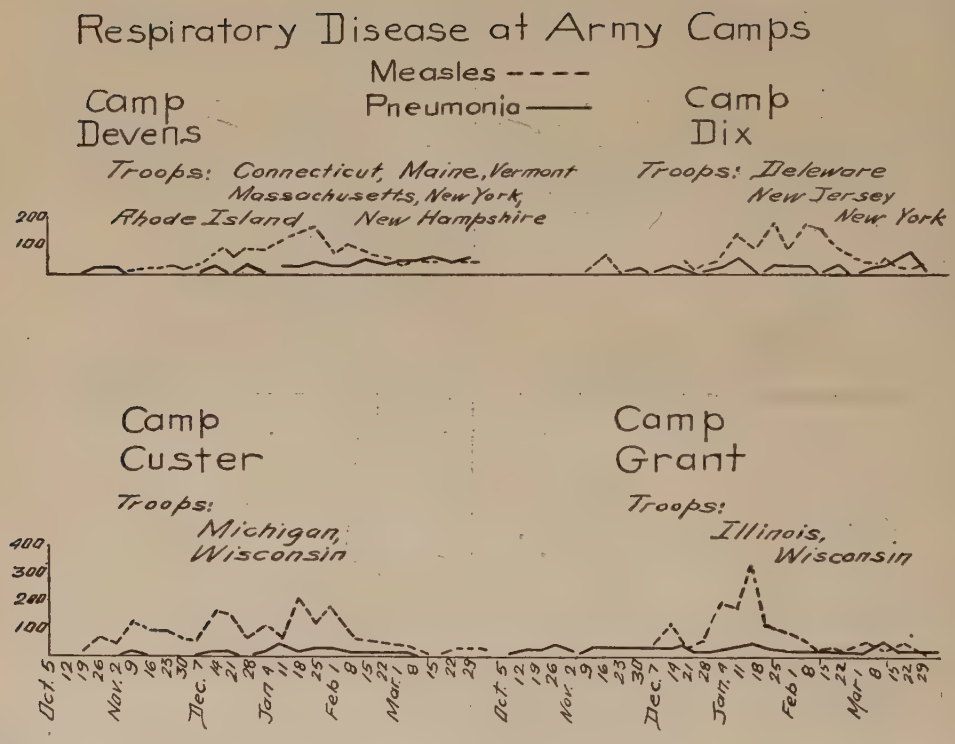
in the same individual. There was not a single instance of second attack of measles, although the shortest possible interval between the previous attack and the subsequent exposure was sixty-five years.

In 1875 measles first reached the inhabitants of the Fiji Islands. The disease was introduced by the King of the Fiji Islanders and his escort, upon their return from New South Wales. The entire population of the islands was estimated at 150,000 and it is officially stated that there were 40,000 deaths from measles in the ensuing period. In certain islands and villages where more exact information was secured, it was found that from twenty-seven to twenty-eight per cent. of the people died. Panic, insanitary conditions and ignorance of how to care for the sick resulted in this high mortality. V. C. Vaughan has remarked that when measles is introduced into a population with a susceptibility of 100 per cent. "it strikes down so many at practically the same time that adequate care for the sick is impossible." The rapidity with which the population is invaded is practically as great as it is during influenza epidemics.

It is the opinion of the author that the phenomenon which contributes chiefly to the occurrence of influenza in epidemics and pandemics, and which causes the characteristic curves of a primary influenza wave, is the absence of any permanent immunity. We have shown in our discussion that no immunity is proven to exist after a year and a half or two years at the most. Measles occurring in a non-immune population spreads through that population with the same high rate as does the influenza. In Charts XXVIII and XXIX we find the curves of incidence of measles in certain of the United States Army camps in the fall and winter of 1917–18. The simplest curve is that for Camp Wheeler. Here the type is similar to that found in the primary wave of influenza. There is a quasi-symmetrical evolution and the concentration is closely grouped around the maximum. The total duration of the epidemic is short, not being much over eight weeks. The troops at this camp were predominantly rural. The disease starting in this group of relatively non-immunes spread rapidly until presumably all susceptible material was exhausted. Compare Camp Wheeler with those camps where the population was chiefly urban. Here the wave is of longer duration, is not as high, the increase is slower, the decrease is more gradual and the concentration is not grouped so closely about the maximum. In the case of the other camps with chiefly rural population, the curve is not as simple as is the case with Camp Wheeler, and there are at times secondary curves as in the case of Camp Bowie, but the essential similarity to the curve at Camp Wheeler and the dif-

CHART XXVIII.




Respiratory Disease at Army Camps
Measles ----
Pneumonia ——
Camp Devens
Troops: Connecticut, Maine, Vermont, Massachusetts, New York, Rhode Island, New Hampshire
Camp Dix
Troops: Deleware, New Jersey, New York
200
100
Camp Custer
Troops: Michigan, Wisconsin
Camp Grant
Troops: Illinois, Wisconsin
400
300
200
100
Oct. 5 12 19 26 Nov. 2 9 16 23 30 Dec. 7 14 21 28 Jan. 4 11 18 25 Feb. 1 8 15 22 Mar. 1 8 15 22 29

ference from the curves at Devens, Dix, Custer and Grant is striking. It may be that the double waves are explained by acquisition of new bodies of troops, by the introduction of new susceptible material. On this question we have no exact information.

This experience was equally true during the Civil war. Although there are no exact reports, it appears that measles prevailed in the Confederate army and was much more highly fatal than in the Union army.

A recurrent influenza epidemic usually takes the form of a secondary wave, particularly so if it follows the primary wave within a short period of time. The difference in the character of the wave is due to the fact that there is still a comparatively large concentration of immune individuals, immunized by having had the disease during the primary spread. The secondary type of the influenza wave corresponds with the measles curves for the urban camps. There are all gradations in influenza from the typical primary wave down to a very much flattened wave of relatively long duration, and even on to the stage of endemicity, with no discernible wave. In 1920 the recurrent epidemic partook more of the form of a primary wave, because in most individuals the period of immunity had been completed by January and February, 1920.

If we could, by some means, induce an immunity which would last for long periods of time, pandemic influenza would disappear from the earth and the disease would be relegated to the comparatively minor position now occupied by measles. The disease would be constantly endemic, frequently breaking out in small epidemics, but never becoming pandemic. This is one object that should be held in view by the immunologists and bacteriologists. But it is not so simple. Even were a successful vaccine discovered, it is doubtful whether any considerable group of the population could be persuaded to take it as often as would be necessary. Universal vaccination against small pox has never been carried out. The same would be true at the present time with regard to influenza.

There is another similarity between measles and influenza. Measles is as infectious as is influenza. It is as readily transmitted and the mode of transmission is probably the same or very similar. In both diseases we are made poignantly aware of the great contagiousness of the disease, and yet in neither disease has there ever been conclusive evidence of experimental transmission from man to man. Several have reported attempts to transfer measles, but in each case the evidence of infection has been incomplete. The work of Hektoen has

been quoted in particular, but Sellards, after carefully reviewing his work, concludes that the evidence of infection is insufficient. Moreover Hektoen's patients were not exposed subsequently to measles infection in the natural way.

SECTION VIII.

The Prevention and Control of Influenza.

Dr. Hamer has visualized the present state of our knowledge of epidemic influenza in a manner which can scarcely be improved upon. We, therefore, quote him at length: "It seems to me that, during the last thirty years or more, we have been making fairly steady uphill progress along the road which constitutes the boundary between the county of epidemiology and the county of bacteriology, and that we have at length reached, at a height considerably above sea level, the foot of the mountain, on the very top of which lies hidden the secret of an 'epidemic constitution,' and now we are face to face with a parting of ways. Straight ahead is the frowning height, its summit in cloud. On the right hand stretches away a fine road skirting the base of the mountain. Along this road we have recently seen Dr. Brownlee whirled away in his new car 'periodogram.' We are all hoping to hear more from him, but as he is still insisting upon the primary, if not the exclusive, importance of continuous variation in the virulence of the germ, we have to realize that for the time Dr. Brownlee's road is going down-hill. On the other hand, on the left, there swerves away, through the territory of the old epidemiology, another fine road, which has been explored more particularly by believers in 'skiey influences.' So far as it has been traced this road is as flat as flat can be, but of course there is always the possibility that after a while it will begin to rise, as it skirts round the mountain, and leads to a good vantage point from which to start climbing. At the risk, however, of being laughed at, I venture to bring under notice the very rough and at first sight unpromising ground directly in front of us. Along this can be seen two obscurely marked sheep tracks proceeding at any rate onwards and upwards. One diverges slightly towards the left hand and it has been followed at various times by De Schweinitz and others, naturalists bent on collecting 'ultravisible viruses;' the second track, directed rather more to the right, has been explored by Reiner, Müller, Massini, Penfold, and others, workers at the problem of discontinuous variation by 'mutation.' As a matter of fact I have reason to believe that two travellers, each of whom follows one of these tracks,

will keep in sight of and after a while will find that they are approaching one another, and will ultimately meet at a small and retired upland farm; then after passing some dogs and following the track until clear of all stone walls, they will come right out in open ground on the face of the mountain and can start straight up the steep. But it must here be pointed out that there remains to be considered a fourth method of approach to the mountain, the most direct of all; but that is by aeroplane and is of course only open to those trained in metaphysics and statistical methods. Investigators thus equipped are able to rise in the air, to survey with careful scrutiny the whole of the ground beneath them and to make the best use of details of information obtained by scouting parties below. It is to be hoped that at no very distant date a survey of the top of the mountain will thus become an accomplished fact. Meantime, those who cannot fly may find useful employment in examining the track beyond the farm. There is the chance there of picking up facts relating to such questions as the 'parasites associated with a parasite,' symbiosis, and the like; take, for example, a suggestion made fourteen or fifteen years ago that the influenza organism may at one time live in association with Pfeiffer's bacillus, at another with the Micrococcus catarrhalis, and so on; or the throat distemper organism may be yoked now with the diphtheria bacillus and now with the Streptococcus conglomeratus. (Is that, I wonder, now to be regarded as a concept or as an occurrence or happening?)"

At best our knowledge of the cause and manner of spread of influenza is fragmentary and insufficient. Attempts to outline a system of control and prevention based upon present concepts are met with many discouragements. The next pandemic will not be prevented. The disease will surely return. If the interval be sufficiently long it may find us quite as unprepared as we were in 1918. Discouraging as the outlook is there are many bright points upon which we must base our hopes for future results.

The difficulties are many: First the *diagnosis* of influenza is difficult either in the individual case or in the form of a mild epidemic. Even in 1918 the identification was often not definitely made until after weeks had elapsed. Second, we know little concerning the *mode of transmission* of the disease. We speak of "respiratory infection." We believe that the transmission is by a mechanism similar to that for measles, but we have never experimentally transmitted either disease. The *short incubation period* places us at a great disadvantage. Were the interval between the occurrence of the first case and the development of additional cases as long as it is in measles, the problem

of isolation and quarantine would be simplified. As in measles the disease is probably *very early infectious*, presumably before acute symptoms develop. The majority of cases of influenza are *ambulatory*. Many individuals do not take to their beds, but continue about their work, spreading the disease wherever they go.

Again, we are ignorant of the *period of infectiousness*. Dr. Meredith Davies has made observations indicating that a patient becomes non-infectious within one week after the temperature has become normal. How many influenza patients remain isolated throughout this period?

A *carrier state* probably exists and plays a most significant part in the spread.

Yet another drawback is the *apparent wide susceptibility* to the disease. Were individuals definitely immunized by one attack the proportion of susceptibles would be lessened, their concentration in a population would be decreased, and the probability of their being exposed would be proportionately diminished.

An additional difficulty is that after an epidemic has once become prevalent, we must combat not only the virus causing the disease but also the *secondary invaders*.

Epidemiologic work has shown that *crowd gatherings* are instrumental in the spread of influenza. The density of population has not been as definitely proven to be a factor. Crowding, however, does play a part. Close crowding in communities must facilitate the spread, but pandemics of influenza were known before the great metropoleis existed. *Hygienic conditions* play their part in the etiology. Finally, in the presence of every serious epidemic we must also combat the *tendency to panic* in the population.

Anticipatory or preventive measures.—It is erroneous today to speak of measures for the prevention of influenza in a community. We cannot prevent the disease. At most, we can anticipate the occurrence of an epidemic and take precautionary measures by which the spread and the severity of the disease may be minimized.

First and foremost comes *education*. Education of the public, of the medical profession and of health authorities. "Scare headlines" in the newspapers during epidemics should be discouraged. Health cartoons are of value, but when they express only partial truths they cannot but do some harm. General education in hygienic methods and in a knowledge of the spread of contagious diseases has already been most productive. Many methods by which the public intelligence could be reached are as yet untried. A daily paper in Boston devotes

two columns a week to a discussion of public health problems, under the title of "The Clinic." The statements appearing in these columns are nearly always the truth and are not exaggerations. There are discussions of recent scientific work of interest to the reading public. As has been emphasized by Carnwath, a page devoted to methods of maintaining the health of the community would probably be of more immediate value than are the many pages devoted to financial statements, "such as the price of Mexican Eagles or of Peruvian Corporation Preference."

The *organization of health services* to combat unexpected epidemics would be of great assistance. In times of peace, prepare for war. In all but the largest cities the health authorities are generally so free from contact with epidemics and are so pressed with routine that they do not organize in readiness for an epidemic which may not come. There should be a closer co-operative organization between health officials and practising physicians, so that the latter may aid to a greater extent in the public health work. The physician co-operates in furnishing information required by the health officer, but too frequently takes little interest in what further is done with this information. The medical profession should be made to understand the importance of public health work, should have a general comprehension of the methods used in its execution and should particularly develop a sympathetic and co-operative mental attitude.

The medical societies of the country should be so organized that at a moment's notice their membership can be mobilized for the defense of the community. There is much that the practising physician does not know about influenza. One of the leading internists in one of our largest cities, during the 1920 epidemic, refused to call his cases influenza and treated them as mild "grip." It is stated that he lost an unusually large number of his patients. There are still many who believe that the two diseases are not identical. Not only is this detrimental to the patient, but as it results in faliure to isolate the sick it is, detrimental to the community.

Nursing groups should be organized to aid at a moments notice.

Much work has been done and great experience gained by both the physicians and the nursing organizations during the last epidemic. Now is the time to prepare for the next epidemic or pandemic. With the remembrance of 1918 fresh in our minds we can establish a working system, while if we delay until the expected arrival of another epidemic much of our painfully acquired knowledge will have been forgotten.

Opinion differs as to whether influenza should be made a *reportable disease.* The added expense would be not insignificant. This particular malady presents the additional complication of being difficult of diagnosis. The records would at best be inaccurate. The author believes that certain experiments in reporting the disease even in inter-epidemic times should be carried out. This should be done by competent epidemiologists who could later formulate plans for the permanent reporting of the disease. We will discuss this further under the heading, "Constructive Research."

The use of *vaccines* has been tried. In 1918 it was almost universally begun too late—after the epidemic had become prevalent. Prophylactic vaccination should be inaugurated before the disease actually becomes epidemic. Vaccination, particularly against the secondary invaders, is entirely rational. It may not prevent influenza, but it may protect against the serious complications in individuals and may prevent to an extent the spread of secondary invaders in the community.

Greenwood aptly remarks that, "In estimating the total effects produced upon morbidity and mortality by disease, the non-specific secondary invaders are as important as the specific causes. The camp followers of an army may do more damage than the regular soldiers, and the same camp followers may ravage in the wake of different armies."

At a conference held at the London War Office, October 14, 1918, the subject of vaccination for influenza was discussed. It was decided that only three organisms should be employed in each case in the preparation of the vaccine; that these races should be recently isolated from cases of the disease developing during the course of the epidemic and that the microorganisms should be submitted to a rigorous study as to race and type. The first dose should include 30,000,000 of Bacillus influenzae, 100,000,000 pneumococcus, 40,000,000 streptococcus; the second dose 60,000,000 Bacillus influenzae, 200,000,000 pneumonococcus, 50,000,000 streptococcus. The vaccine should be sterilized at 55° C. and one-half per cent. phenol should be added. The administration should be at ten days' intervals.

In the United States the vaccines employed have often contained a greater variety of organisms. It is unnecessary to enumerate the results obtained by various investigators. Some have been mildly enthusiastic, while others have obtained no demonstrable benefit. It will suffice to say that there has been no clear evidence that vaccination has been beneficial, but that the procedure has not been given a

thorough trial. If the causative organism of the disease is eventually determined, vaccination will probably be attempted with it as antigen. For the success of vaccination it is important that practically entire communities be inoculated, and that they be so inoculated before the development of epidemic prevalence.

Palliative measures in the presence of an epidemic.—An epidemic, once having obtained a start will run its course. Our attempts will be to lessen its extent and diminish its explosiveness. Or, more probably, we will best succeed by *extending* the duration and making the invasion less explosive. We must know of its earliest appearance. *Notification* must be made by physicians to the health authorities in order that the earliest increase may be detected. This again renders the reporting of the disease at all times an essential feature. The *administrative control* and the *publicity* to be given have already been discussed.

What general measures should be taken against the disease? Should the *public schools* be closed? Winslow and Rogers found that the orthodox methods of combating epidemics applied in Connecticut exerted no appreciable influence on the spread of influenza. Bridgeport, Hartford and New Haven *did not close* their schools and suffered from death rates near the average for the State, lower than the rates which prevailed in cities like New London and Waterbury, which closed their schools. No deductions can be drawn from this fact, however, because the closing of the schools in most cases was forced because of the severity of the outbreak.

The data obtained by Jordan indicate that schools were not important distributing centers for the infection. No explosive outbreak occurred in any one grade, and the four days of the Thanksgiving holiday evidently afforded more favorable opportunities for infection than did the days of regular school attendance.

Carnwath believes that in view mainly of the marked prevalence of the disease amongst school children, the balance of opinion is in favor of closure, even in densely populated urban districts. In the author's investigation there was a slightly higher incidence of the disease among children attending school than among those younger children who were not at school. The spread is probably not facilitated so much in the class room as it is on the play ground. In the school room the children are constrained to remain at a certain distance from each other. Probably they would come into as close contact with cases if they were not at school. Certainly it has not been demonstrated that the school room is a factor of great importance in the spread of influenza. It would, perhaps, be better not to close the

schools in the presence of an epidemic, but to discontinue any congregation on the play grounds, and to discourage the grouping of children in play on the streets.

With children and with all individuals, large or small, a great factor in exposure and probably in the transmission of the disease is the necessary *crowding on street cars and in public buildings.* Here is a potent source which requires deep study and new treatment. Some cities have with partial success attempted lessening the congestion in public conveyances at the beginning and closing of business hours by arranging with the various offices, stores, etc., that the opening and closing times occur at different hours. In order that this procedure may work it is important that the employees of a factory or store which closes early must ride to their destination at the time of closing and not remain in the congested business districts. Here again it is a problem of educating the public to a point where they will co-operate intelligently.

It has been amply demonstrated that *crowd gatherings* markedly facilitate the spread of the disease. Mass meetings should be prohibited and gatherings in and out of doors should be discouraged. The public should be taught that the safest place is at home.

What *instructions* can we give *to the individual* for his own protection? There are at least six precautions based on scientific knowledge. They are:

First: Avoid crowds.
Second: Avoid crowding in the family.
Third: Sleep alone.
Fourth: Pay particular attention to personal hygiene.
Fifth: Boil all dishes, etc., after meals.
Sixth: Do not eat in insanitary restaurants. Eat at home.

Should cases be *isolated?* Should they be *quarantined* until no longer infective? The experience of the last epidemic has rendered us pessimistic. We have found that isolation and quarantine does little or no good. Institutions which were held under rigid quarantine for the first months of the epidemic were later invaded when discipline became lax. The disease thereafter spread often as extensively as it would have, had there been no delay. But, on the other hand, there is record of some institutions in which the quarantine lasted throughout the epidemic and in which the inmates never became ill. All of our past experience with infectious diseases leads us to believe that isolation of cases should be enforced. The experience of 1918 should not cause us to change from this point of view. Up until now the pro-

cedure has been without results. It has been nearly impossible to enforce it. Further study must be made before any definite conclusion can be reached.

The same in general may be said regarding *disinfection* after recovery of a case of influenza. Today most people believe that disinfection is unnecessary. The work of Lynch and Cumming, if correct, would indicate the contrary. The possibility of transmission through inanimate objects has not as yet been completely eliminated.

The *efficacy of face masks* is still open to question. Certainly the face mask as extensively used during the 1918 epidemic was of little benefit and in many cases was, without doubt, a decided detriment. The same mask was worn until it was filthy. It was not worn in such a way as to be a protection. Even had the nose and mouth been efficiently protected, the conjunctivae remained unprotected. The work of Maxcy and of Vincent and others has demonstrated the importance of the naso-lachrymal duct as a possible portal of entry into the respiratory tract proper. After cultures of Bacillus prodigiosus were sprayed upon the ocular conjunctivae these organisms have been recovered from the nose within five minutes, from the nasopharynx within fifteen minutes and from the feces within twenty-four hours. One difficulty in the use of the face mask is the failure of cooperation on the part of the public. When, in pneumonia and influenza wards it, has been nearly impossible to force the orderlies or even some of the physicians and nurses to wear their masks as prescribed, it is difficult to see how a general measure of this nature could be enforced in the community at large. If masks are to be used they should be employed in the same manner as for protection against the plague. They should be made to cover the entire head. This procedure has been recommended particularly by Vincent and by Thorne.

It is safe to say that the face mask as used was a failure.

Problems for the future. Constructive research.—While pure epidemiologic study of influenza will not demonstrate the causative agent, it is the chief procedure upon which we can at present rely for improvement in our methods of combat. Many important laboratory contributions have been made during the last two years. The majority have been without immediate value to the health officer. The author suggests in the following paragraphs a plan of study, based upon past epidemics and the experiences of the last pandemic, as epitomized in the preceding chapters. During the exposition of this subject we have drawn certain conclusions and have developed some theories. We believe that they explain the facts correctly, but should

the hypotheses prove not entirely correct the value of the following outline for study will be in no way impaired.

To become thoroughly acquainted with epidemic influenza in all its manifestations would require a life time of study. Knowledge of the disease would be greatly furthered if competent epidemiologists should see fit to devote their entire time to a study of the disease in its various ramifications. The author suggests a research organization of individuals whose function it would be to become completely acquainted with influenza. The organization should be under the direction of a competent board of epidemiologists. Under them would work several groups composed of epidemiologists, bacteriologists and others. There should be sufficient groups so that they might be distributed to diverse regions of the earth. They should be equipped for travel, with mobile bacteriologic laboratories and all the necessary equipment for epidemiologic surveys, so that at a moment's notice they could proceed to wherever an epidemic of any disease simulating influenza is reported to be prevalent. The working groups would be under the administrative control of the central directors and would make their reports to them. All groups should be so distributed geographically as to have easy and rapid access to any community in which an epidemic might occur. They would keep themselves informed concerning the disease prevalence in all communities under their jurisdiction. This would be done through the co-operation of the civil health authorities and through the utilization of all other available sources of information. The central board should be constantly in touch with the groups, so that the infectious disease prevalence in all parts of the world would be known at all times.

Had such an organization been in existence during the last thirty years, every one of the so-called influenza epidemics reported in one place or another would have been investigated. Detailed epidemiologic, statistical, demographic and bacteriologic reports would have been made. It matters little how small or insignificant the outbreak appears to be. Even the smallest have their characteristic features and are worthy of study. If we study epidemic influenza but once in thirty years, we will never become well acquainted with the disease. We must see it repeatedly and frequently. If it does not exist during the intervals we must study the diseases simulating it. It is surprising how much of the knowledge acquired in 1889 was forgotten by 1918. Even some of the more important features had passed from memory. Thus we find statements in 1918 that the age morbidity was quite different from that in all preceding epidemics. Research into the literature of the past does not corroborate this impression.

If influenza is scattered throughout the earth in mild form, it would avail us but little to send a commission to Bokhara to study the endemic focus supposed by some to exist in Turkestan. Even though the disease were endemic in that country, one would not expect to discover epidemics there. The general immunity of the population in the endemic area is probably increased. Nevertheless one unit might well be stationed in Turkestan, there to study the existing conditions regarding infectious diseases.

There would be ample work for all groups at all times. The study would not be limited to a consideration of infectious diseases. Sociologic conditions may be of importance. We have recorded instances of this. Wherever there is an unusual concentration of large masses of individuals the investigators should study the results of such concentration.

An advantage of this organization would be that the groups through their central bureau would establish an information bureau of infectious disease prevalence analogous to the popular weather bureau of today. They would report the presence of a cloud before it had appeared on the local horizon.

In the absence of any epidemics resembling influenza, there would be abundant opportunity for correlated work. We have mentioned the epidemiologic resemblances between influenza and certain other infectious diseases. Comparative study of any or all of them is of importance. The bacteriologist and the immunologist would find plenty of material in the study of measles prevalences. The two diseases are so similar in their manner of spread, in the probable mode of transmission, in their clinical characteristics and in the results of laboratory attempts at transmission, that one must assume that the causative viruses are not dissimilar. Any new facts that we may gain concerning measles will be of value in the study of influenza.

Many years could be well devoted merely to a study of immunity in influenza.

The results obtained by this proposed organization for the investigation of influenza would be slow in achievement. The study is not of a type calculated to appeal to the popular imagination. Communities in which the dread of an iminent pestilence is not present would subscribe with some hesitation to appeals for pecuniary assistance. Fortunately, however, there are in existence several organizations already well developed along these lines, organizations chiefly interested in certain other diseases. There can be no doubt but that at the present time the financing of such a broad project could be

arranged, and that the groups could be efficiently organized on the basis of experience already gained in similar projects.

Crookshank well remarks that our present epidemiologic intelligence service is hardly superior to that of a Meteorologic Office which only gives warning of rain when unfurled umbrellas pass along the street. Influenza will surely return. There will be mild epidemics within the next few years. In time another pandemic will arrive, and after it will come pandemic after pandemic. In 1918 as in 1889 we were caught unprepared. Let us do our utmost to prevent the recurrence of this tragedy. To delay is to loose the valuable information gained during the last two years. The future is not without well grounded hope, but success will not be achieved until we have attained a much deeper understanding of the epidemiology of influenza.

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APPENDIX

Form A—Family Record
Date first visit
Data obtained from

Address
Householder's name

File No.

	Census of Occupants				Influenza					
	NAME	Stock	Sex	Age	Status	1918 Date	Severity	1920 Date	Severity	
1										
2										
3										
4										
5										
6										
7										
8										
9										
10										
11										
12										

Form A.—Household record, used in Boston influenza census. (See page 127.)

Housing Data

Type of Dwelling	Location of apt._____	Economic Status
Detached_____	No. rooms_____	Well to do_____
Terraced_____	No. bed rooms_____	Moderate_____
Duplex_____	No. in ea. bed room____	Poor_____
Apartment_____	Entrance	Very poor_____
Tenement_____	Common_____	Sanitary Status
Height_____stories	Separate_____	_____
No. of households_____	Toilet_____	_____
	Common_____	_____
Sig._____	Separate_____	_____

Date	Return Visits Remarks

FORM A.—*(Continued.)*

Date first visit _____ Address _____ File No. _____

Data obtained from _____ Name _____

Occupation _____ Business address _____

Influenza 1918 — **Illnesses during 1920**

	No	Yes
Month		
Onset	Sudden	Gradual
Fever		
Prostration		
Headache		
Backache		
Pain in extremities		
Pneumonia		
Sick how long		
Days in bed		

Name of Hospital _____ Social Service? _____

Influenza vaccination _____

Name of M. D. _____

Pneumonia history _____

Inter-epidemic illnesses

Diagnosis	Month	Duration

Exposures to Influenza, 1918

Address 1918.

Sig. _____

Physician's diagnosis	
Date	
Hour	
Onset (sudden or gradual)	
Chills	
Chilliness	
Fever	
Prostration	
Headache	
Backache	
Pain in extremities	
Painful eyes	
Dry throat	
Sore throat	
Coryza	
Hdkf. per day	
Epistaxis	
Nausea	
Vomiting	
Diarrhœa	
Cough (date)	
Sputum	
Scant	
Abundant	
Frothy	
Bloody	
Purulent	
Pneumonia	
Days sick	
Days in bed	
Other symptoms	
Severity	
Sleep alone?	
Infection source	

FORM B.—Individual Record obtained for each person in every family canvassed, whether the individual gave a history of influenza (1918 or 1920) or not. (See page 127.)

Return visits	
Date	Remarks (Health; exposures—sleeping, familial, casual, public)

FORM B.—(*Continued.*)

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